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IN THE

Supreme Court of the United States

Nos. 2, 3 and 4, Original

OCTOBER TERM, 1940

States of Wisconsin, Minnesota, Ohio and Pennsylvania, Complainants, *vs.* State of Illinois and the Sanitary District of Chicago, Defendants.	No. 2, Original
State of Michigan, Complainant, *vs.* State of Illinois and the Sanitary District of Chicago, et al., Defendants.	No. 3, Original
State of New York, Complainant, *vs.* State of Illinois and the Sanitary District of Chicago, et al., Defendants.	No. 4, Original

REPORT OF THE SPECIAL MASTER

March 31, 1941

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REPORT OF THE SPECIAL MASTER

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I.

PRELIMINARY STATEMENT

History of Litigation

On May 9, 1922, the original proceeding in this cause was begun when the State of Wisconsin moved for leave

to file a bill for an injunction to prevent the State of Illinois and the Sanitary District of Chicago from diverting water from Lake Michigan at Chicago. The States of Minnesota, Ohio, Pennsylvania, Michigan and New York subsequently joined as complainants or filed independent bills. After a reference to Charles Evans Hughes, Esq., as Special Master, the Court on January 14, 1929, rendered an elaborate opinion through Chief Justice Taft (278 U. S. 367), holding the diversion of water from Lake Michigan to be illegal, except insofar as it might be required to maintain navigation in the Chicago River.

The case was again referred to Special Master Hughes for a report upon the practical measures necessary for the disposition of the sewage of the Sanitary District through other means than the diversion of water from Lake Michigan, the time which would be required therefor, what reduction in diversion would meanwhile be practicable, and the diversion which would be permanently necessary to maintain navigation in the Chicago River.

On April 21, 1930, following the report of the Master upon this reference, a decree was entered pursuant to an opinion of Mr. Justice Holmes (281 U. S. 696), enjoining the State of Illinois and the Sanitary District of Chicago from diverting any of the waters of the Great Lakes-St. Lawrence System or watershed through the Chicago Drainage Canal or otherwise in excess of the following annual averages, in addition to domestic pumpage:

From July 1, 1930 to December 31, 1935	6500 c.f.s.[1]
From December 31, 1935 to December 31, 1938	5000 c.f.s.
From December 31, 1938	1500 c.f.s.

On October 10, 1932, (287 U. S. 568) upon the ap-

[1]C.f.s. will be used in this report as an abbreviation for cubic feet per second. One cubic foot per second is approximately two-thirds of a million gallons per day.

plication of the complainants, Illinois and the Sanitary District were ordered to show cause why they had not taken appropriate steps to effect compliance with the requirements of the decree of April 21, 1930. After a reference to Edward F. McClennen, Esq., as Special Master, the Court, through Mr. Chief Justice Hughes, handed down an opinion enlarging its original decree by directing the State of Illinois to take all necessary steps, including the provision of necessary moneys, to secure the completion of adequate sewage disposal plants, together with any necessary controlling works to prevent reversals of the Chicago River (289 U. S. 395).

On January 11, 1940, Illinois applied for a modification of the decree entered on April 21, 1930, to permit a temporary increase of the diversion to 5,000 cubic feet per second, in addition to domestic pumpage, until December 31, 1942. After a hearing upon this application, the Court on April 30, 1940, rendered a *per curiam* opinion (309 U. S. 569), in which it said:

> "The State of Illinois has failed to show that it has provided all possible means at its command for the completion of the sewage treatment system as required by the decree as specifically enlarged in 1933 (289 U. S. 395, 710). No adequate excuse has been presented for the delay. Nor has the State submitted appropriate proof that the conditions complained of constitute a menace to the health of the inhabitants of the complaining communities or that the State is not able to provide suitable measures to remedy or ameliorate the alleged conditions without an increase in the diversion of water from Lake Michigan in violation of the rights of the complainant States as adjudged by this Court.
>
> "In order, however, that the Court may be satisfied as to the actual condition of the Illinois

Waterway by reason of the introduction of untreated sewage, and as to the actual effect, if any, of that condition upon the health of the inhabitants of the complaining communities, and also with respect to the feasibility of remedial or ameliorating measures available to the State of Illinois without an increase in the diversion of water from Lake Michigan, the Court appoints a Special Master to make a summary inquiry as to such condition, effect and measures, and to report to this Court with all convenient speed."

Modification of the Petition of Illinois

After the hearings before me had been completed, Illinois in the brief which it submitted to me and the findings which it requested me to enter, modified its petition so as to ask for an additional diversion during the months from April to October, in each of the years 1941 and 1942 to the extent necessary to provide a minimum of 1 part per million[1] of dissolved oxygen in the water above the dam at Brandon Pool at Joliet, subject to the following maximum increases above the 1500 c.f.s. now permitted:

	1941	1942
April	1000	0
May	3000	2000
June	5000	4000
July	6000	5000
August	5000	3000
September	3000	1000
October	1000	0

According to the schedule set out by Illinois in its modified petition, the total increase in diversion of water, if the modified application were granted, would amount, on an annual basis, to 2,000 c.f.s. in 1941 and to 1,250 c.f.s. in 1942.

[1]Parts per million will be hereinafter referred to as p.p.m.

Conduct of the Hearings

On July 8, 1940, accompanied by counsel for all parties, I went by automobile from Chicago to Joliet, Ill., a distance of about 45 miles by road (the distance by rail is about 40 miles), and there at a point below the Brandon Road Dam, took a boat provided by the Sanitary District and proceeded through the Brandon Road Pool, a distance of about 5 miles. On July 10th, accompanied by counsel, I made an inspection of the sewage disposal plants situated on the West Side and the Southwest Side. The taking of testimony was begun in Chicago on July 11, 1940 and continued through July 12. Beginning July 22, 1940, I spent four days at Joliet, where the testimony of a large number of witnesses was taken, and upon this visit I again took a boat and made an inspection of the Waterway from the Brandon Road Dam to the Lockport Dam. I also drove by automobile along the Canal to Lockport. While the testimony was being taken at Joliet, I resided at the Louis Joliet Hotel, which is four blocks from the Canal.

The taking of testimony was resumed in Chicago in September, 1940, and hearings were had from time to time in September and October. Another hearing was held in Chicago in January, 1941, primarily for the purpose of recording the results of the experimental flow of 10,000 c.f.s over a period of ten days which was authorized by the Court's order of November 25, 1940, as well as for the purpose of receiving final reports as to the status of the sewage disposal works and the conditions in the Waterway.

Argument was heard in New Orleans on February 20, 21 and 22, 1941. Additional documentary evidence was then received. Full briefs and reply briefs

were filed on both sides. The record comprises approximately 4,000 pages. The total number of witnesses heard aggregated 161. A large number of exhibits were received.

II.

HISTORICAL AND PHYSICAL DETAILS CONCERNING WATERWAY AND DIVERSION FROM LAKE MICHIGAN

General Description of Illinois Waterway

Full historical details with respect to the Waterway are to be found in the original report of Special Master Hughes filed on May 23, 1927, some of the facts stated in which are summarized in the opinion of Chief Justice Taft reported in 278 U. S. 367. Only a few of the more important facts will be noticed here.

The Illinois Waterway extends from Lake Michigan at Chicago to the Mississippi River at Grafton, Ill., a distance of approximately 327 miles. It comprises the Chicago River, the Chicago Sanitary and Ship Canal (an artificial channel constructed by the Sanitary District of Chicago[1]) and the Des Plaines and Illinois Rivers. The Canal Section was constructed between 1892 and 1900 and was opened for use on January 17, 1900. Up to that time the Chicago River flowed into Lake Michigan, carrying with it the sewage of Chicago, which was discharged into the river. The river before 1865 "in its natural state was a sluggish stream, especially in its lower reaches. Receiving the sewage of a rapidly

[1]The Sanitary District was organized under the Illinois Act of 1889 and its organization was completed in 1890. Its area comprised 185 square miles extending from the Illinois State line on the south and east to the northern boundary of Cook County on the north, with about 34 miles of frontage on Lake Michigan, thus embracing the metropolitan area of Chicago, consisting of Chicago and its suburbs. The area now comprises 442 square miles.

growing city, together with the waste of industrial plants, it became very offensive"; see 1927 report of Special Master Hughes, page 12. In 1872 "the canal was grossly polluted", *ibid*, page 13. In 1891 "as the city continued to grow the nuisance along the canal was at times as bad as ever", *ibid.*

After the Canal was opened, the flow of the Chicago River was reversed so that it was made to flow away from Lake Michigan. All sewage in the District was turned into the main channel, completely untreated.

In January, 1900, the State of Missouri filed a suit in this Court against Illinois to restrain the discharge of sewage by Chicago into the Illinois River on the ground that it came from the Illinois River to the Mississippi River at a point about 43 miles above the City of St. Louis and might endanger the health of the inhabitants of that City. A demurrer to the bill was overruled; *Missouri vs. Illinois*, 180 U. S. 208; decided January 28, 1901. The case was then heard on the merits and a decree entered on February 19, 1906, dismissing the bill on the ground that the complainant had failed to establish the allegations of the bill, particularly in view of the considerable distance from the origin of the sewage to Missouri and the oxidizing qualities of the water from Lake Michigan and the Mississippi River; *Missouri v. Illinois*, 200 U. S. 496.

The Canal Section of the Waterway extends from the Chicago River at Damen Avenue (sometimes called Robey Street), which is about 6 miles from Lake Michigan, and extends thence 30 miles to Lockport. Two miles west of Lockport the Canal connects with the Des Plaines River. Further south the stream is joined by the Kankakee River and becomes known as the Illinois River.

Since 1930 a controlling works and lock have been

constructed by the Sanitary District at the mouth of the Chicago River to prevent reversals into Lake Michigan.

From Grafton to just below Lockport (a distance of approximately 290 miles) the Waterway is generally 300 feet wide and 9 feet deep. From Lockport to Chicago Harbor, the channel is generally 160 feet wide and 21 feet deep.

A series of dams and locks with resulting pools above the dams have been constructed in the Waterway in order to assist navigation by eliminating rapids in the stream. In the order in which they are approached from Chicago, these are situated at Lockport, Brandon Road Pool, Dresden Island, Marseilles, Starved Rock, Peoria, LaGrange and Alton. All of these are now operated by the federal government. At the time of the rendition of the 1930 decree of this Court, the Lockport Dam and Pool were in existence, but not the others. The section of the Waterway directly involved in the present controversy contains only the pools at Lockport and Brandon Road. The Brandon Road Pool is situated at Joliet and appears to be the chief source of the complaints at this time. Further details with respect to it are accordingly here noted.

Brandon Road Pool

The construction of Brandon Road Lock and Dam was begun by the State of Illinois but taken over by the federal government in 1930. It was completed in 1933. Prior to its creation there was an old dam at Jackson Street in Joliet, and the Des Plaines River between that point and the Brandon Road Bridge flowed rapidly over rocks, creating considerable turbulence. The channel was comparatively narrow, varying in depth from a minimum of 1 to 2 feet to a maximum of 6 to 8 feet, and navigation was possible only through the old Illinois and Michi-

gan Canal. As technically defined by the United States Engineers, the Brandon Road Pool extends from the power house of the Sanitary District near Lockport to the Brandon Road Dam just below Joliet, a distance of approximately 5 miles. For the greater part of the distance, however, the Pool is not much wider than the Waterway. At a point below the McDonough Street Bridge at Joliet, the width expands from approximately 270 ft. to a maximum of 1,400 ft. The maximum width extends for about half a mile. The Joliet city map indicates that this wide section of the Pool is at the southern end of Joliet, for the most part outside the corporate limits, and it appears to be one to two miles from the residences of most of the Joliet witnesses. It is this lower wide section that is generally referred to as the Brandon Road Pool.

Diversion from Lake Michigan

Including domestic pumpage, the water directly abstracted from Lake Michigan by the Sanitary District in earlier years ranged from 2,990 c.f.s. in 1900 to 7,839 c.f.s. in 1913 (1927 report of Special Master Hughes, p. 22). The quantities thus abstracted substantially exceeded the amounts authorized by permits issued from time to time by the Secretary of War. In October, 1913, the United States brought suit against the Sanitary District in the District Court for the Northern District of Illinois, to enjoin the Sanitary District from diverting more water than that authorized by the permit then outstanding, which allowed a maximum diversion of 250,000 ft. per minute, equal to 4,167 c.f.s., including domestic pumpage. After many years of delay, a decree was entered in favor of the United States on June 18, 1923, which was affirmed by this Court in an opinion rendered on January 5, 1925, by Mr. Justice Holmes; *Sanitary District of Chicago vs.*

United States, 266 U. S. 405. The decree was without prejudice to any permit that might be issued by the Secretary of War.

Following this decision, on March 3, 1925, the Secretary of War issued a permit authorizing the diversion of an amount not exceeding 8,500 c.f.s. in addition to domestic pumpage. This permit expired by limitation on December 31, 1929, and the Secretary of War then issued a permit for 8,500 c.f.s., including domestic pumpage, to expire June 30, 1930. This permit was in effect set aside by the decree entered by this Court on April 21, 1930, in the injunction suit filed by Wisconsin and other Lake States (281 U. S. 696), and the Secretary of War on June 26, 1930, issued a permit to conform with the Court's decree, which provided for a reduction of the flow as stated, *supra*, *page* 2.

The decree of April 21, 1930 provided that the amount to be diverted was to be determined by deducting from the total average flow at Lockport the amount of domestic pumpage, i. e. water pumped from Lake Michigan by the City of Chicago into its water mains. During the years 1938, 1939 and 1940 the (a) total average monthly flow at Lockport and (b) Chicago domestic pumpage were as follows in c.f.s.:

	1938	1939	1940
Average total flow at Lockport	6,648	3,132	3,319
Domestic pumpage	1,604	1,620	1,589
Inflow from Des Plaines River	45	13	49
Net water taken from Lake Michigan, exclusive of domestic pumpage	4,999	1,499	1,681

The 1940 figures were increased by the temporary flow of 10,000 c.f.s. for a period of ten days from December 2 to December 12, 1940, permitted for experimental purposes in accordance with the stipulation of

the parties, by the Court's order of November 25th, 1940 to which further reference is hereinafter made. Excluding this 10-day experimental period, the 1940 total flow at Lockport averaged 3,138 c.f.s., and the domestic pumpage 1,592 c.f.s., leaving a net amount diverted from the Lake, in addition to pumpage and excluding the 10-day experimental flow period, of 1,546 c.f.s.

III.

COMPLAINTS AND HEALTH CONDITIONS ALONG WATERWAY

Complaints of Lay Witnesses at Joliet

The complaints as to the Waterway which were presented to me emanated entirely from residents of Lockport and Joliet, and chiefly from the residents of Joliet. Lockport is situated on the Waterway about 35 miles from Chicago. Joliet is similarly situated about 40 miles from Chicago.

The population of Joliet was reported in the last three censuses as follows:

1920	38,414
1930	42,993
1940	42,365

The Health Commissioner of the City estimated the number of people living in Joliet and surrounding territory who were likely to be affected by health conditions in and near Joliet at 50,000. A number of large industries are situated in the city and several important railroads traverse it. The Des Plaines River joins the Waterway just below Lockport, three or four miles above Joliet. The Waterway flows through Joliet and is crossed by eight bridges there.

No water from the Waterway is used for drinking purposes and there is no swimming in it. All of the complaints were based upon the offensive odors from the Canal and the effects ascribed thereto. The complaints proceeded almost entirely from persons residing alongside the Canal or near it.

A total of 127 witnesses appeared before me during the four days of the hearings at Joliet, made up as follows:

Lay residents of Joliet	81
Physicians residing in Joliet	15
Nurses and employees of St. Joseph's Hospital at Joliet	24
Lay residents of Lockport	7[1]
	127

On the fourth day of the hearings at Joliet, in order to avoid cumulation of testimony, it was stipulated that if 200 additional witnesses were called, they would testify substantially along the same lines.

Of the 81 lay witnesses residing at Joliet who appeared before me in person, 38 were men and 43 were women. The residences of these witnesses with respect to the location of the Canal may be thus summarized:

Within two blocks of the Canal	46
Within three blocks	10
Within four blocks	4
Within five blocks	2
Within one-half mile	7
Within one mile	4
More than one mile	5
Not stated	3
	81

Thus, approximately three-fourths of the witnesses

[1]Included in the Lockport figure are the United States Lock Master at Lockport and his assistant, whom I encountered upon a tour of inspection. They were not subpoenaed by Illinois, but I took their testimony on my own initiative as to the conditions at Lockport; they found no cause for complaint.

resided within four blocks of the Canal, and more than half within two blocks. Their residences were within one to two miles of the wide portion of the Brandon Road Pool, which, below the McDonough St. Bridge, extends to a width of 1400 feet for a distance of approximately half a mile.

The complaints were generally to the effect that the Canal in the hot summer months of 1939 gave off extremely offensive odors, which, in the case of many of the witnesses, caused them or members of their family to suffer from nausea, lack of appetite and inability to sleep. Some who complained of nausea had no trouble in sleeping; others complained of inability to sleep and not of nausea.

A substantial number of the witnesses who complained that the odors caused lack of appetite or nausea appeared to be overweight. A number of the witnesses said that they suffered no ill effects themselves, but testified as to the ill effects suffered by members of their family.

The character of the odors was described by various witnesses as the odor of sewers or outhouses or of rotten eggs. Many witnesses used the general terms, "terrible", "vile", "very offensive", "unbearable".

All of the witnesses agreed that the Canal had always given off objectionable odors (as would be expected from a stream into which untreated sewage has for many years been deposited), but, with practically no exceptions, they testified that in 1939 the odors were much more offensive and disturbing than they had been in previous years[1]

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[1]In their brief before me counsel for Illinois said (p. 17):

"* * the State of Illinois admits that conditions were never wholly satisfactory even prior to 1939, but insists that the conditions did not become acute or serious until December 31, 1938 when the diversion was cut from 5,000 c.f.s. to 1,500 c.f.s."

A former lieutenant governor of Illinois testified that he had lived within about 3 blocks of the Canal for about 34 years; that there had been "disagreeable odors" from the Canal from time to time in the past "but the odor now seems to be a combination of unpleasant, disagreeable and nauseous odors". The witness further testified:

> "I have believed that we who are here locally are becoming somewhat immune to this condition, that it is more noticeable when strangers, visitors, come to the place. I believe that there is a feeling that residence within the close proximity to this channel is not desirable and, maybe, possibly affects the valuation of property in the immediate vicinity of the channel."

Asked if he had ever known of any illness or temporary discomfitures traceable to this condition, the witness replied:

> "No, I don't think so, save the psychological effect that it would have on a person who might attribute his illness to that and, believing in it, would, perhaps, become more or less of an invalid from a psychological effect, perhaps a state of mind."

Practically all of the witnesses were agreed that the odors from the Canal were much worse in the summer of 1939 than in 1938, which was ascribed by the witnesses to the fact that the diversion from Lake Michigan was cut on December 31, 1938, from 5,000 c.f.s. to 1,500 c.f.s.

There was some difference of opinion as to how the conditions in 1940, when the witnesses were testifying, compared with those in 1939, but the great weight of the testimony was that conditions in July, 1940, when the testimony was given, were better than they had been in 1939. Some of the witnesses

ascribed this to the fact that the weather had not been as hot in 1940 as in 1939, without referring to the fact that the treatment of sewage at the plants of the Sanitary District had advanced substantially since 1939. A number of witnesses were of the opinion that the odors were as bad in 1940 as they had been in 1939, and a few thought that they were worse in 1940.

All witnesses examined on the subject agreed that the odors were worse when the weather was hot. A number testified that they were worse when the weather was humid and sultry and after rains. The witnesses were also agreed that the odors were intermittent, not constant; that they were more noticeable when boats or barges moved through the water and stirred up the water; and that they were also worse at night or in the early morning than during the day.

A number of the witnesses testified that the water was dirty and black and that they had observed thick scum on the Canal in 1939. A photograph offered by Illinois taken in June, 1939, at a point between Summit and Willow Springs (about 20 miles above Joliet) showed considerable scum. A photograph taken by the opposing States at the same point in September, 1940, showed no scum. The testimony indicated that scum was also noticed in earlier years, but not to the same extent as in 1939.

There were approximately a dozen complaints of sore throat and nose or sinus trouble.

Two witnesses testified that their children had asthma.

The family of one witness had diarrhea; the children of another had a summer complaint. The grandchildren of another had dysentery.

Another witness testified that his children became

sick from the odors without specifying the nature or duration of the illness.

One witness who jumped into the Canal to rescue a man who was trying to commit suicide, had skin trouble, which cleared up under treatment. The pilot of a deck-boat had some sores on his lips, which were made worse by water or spray splashing against his lips and "the doctor thinks it might have been that water". Apparently the sores cleared up and no time was lost from work because of them. The witness testified that during the six years he got "sick to my stomach" every once in a while. It was not entirely clear from his testimony whether he thought conditions much worse in 1939 than in other years.

A diver employed for many years by the United States Engineers to work upon the Waterway testified that the gases were worse than they had been and the water was blacker and contained more muck. The brass on his diving suit had turned black. His health is good.

A lockman employed at Brandon Road could not eat his lunch on two hot days in July, 1940; the water is black since they cut the flow and the fish die. "Oh, my health is pretty fair, only when them obnoxious gases and odors come up once in a while, it pretty near turns your stomach. We work right along the locks though." He has had no sick leave for several years.

A young woman employed as a school teacher had a scar on her foot that she received from a fly infection which she blamed upon the water though it does not appear that she had had any direct contact with the water.

A teacher of sixth grade children, of the average age of eleven, at a school situated about 3 blocks from the Waterway, testified that the odors were terrible in June,

1939, and the children were made very restless and hard to keep at work. Another teacher, the principal of the McKinley Public School situated within 600 feet of the Canal, where the children are in the first six grades, ranging up to an average of 12 to 13 years old, testified that the odors were very offensive in 1939, and the teachers complained that they had to shut the windows in order to keep the children's minds on their work, and they were restless. Children have become suddenly sick with nausea. Two or three at a time would be taken out of their classes, sent home and were kept home for a day or so. The witness thought that the conditions were worse in 1939 than in other years.

A woman who lived about half a block away, testified that the gas from the Canal had ruined the paint on the homes in the neighborhood, turned it all black; this happened in 1939 and some of her glassware had been discolored.

The witnesses agreed that the odors were not as noticeable at a distance from the Canal as near it. Some of the witnesses drove out at night during the summer to avoid the odors. Many of them testified that they kept their windows closed to keep the odors out.

Only a small proportion of the witnesses testified that they had had any occasion to consult a doctor, and it did not appear that anyone was confined to bed by illness which could be attributed to the Waterway. Most of the witnesses were working people and members of their families. Most of them rented the houses in which they lived, under leases running from month to month.

Testimony from St. Joseph's Hospital

St. Joseph's Hospital is situated in Joliet about a block and a half to two blocks from the Canal on the west side. It covers an area of about two square blocks and

has about 220 beds. It is operated by the Franciscan Order of the Sacred Heart and has been in its present location since 1875 or 1876. The Silver Cross Hospital is also located in Joliet, but apparently not close to the Waterway; no witness from it appeared before me.

In the hearings at Joliet, testimony was given by 15 Sisters occupying various positions at the hospital and also by 7 lay nurses and 1 resident intern. Their testimony was to the general effect that the odors from the Canal were extremely offensive in 1939 and caused to many of them, and to many of the patients, nervousness, nausea, vomiting, inability to sleep and headaches. Some of the patients are anxious to go home because of the odors, and some of them are so anxious to leave the hospital that they go before their sutures have been removed. Some of the Sisters and nurses complained that their throats became sore or dry, and some had sinus trouble. Windows in operating room have to be kept shut to keep odors out. Windows also have to be kept shut at times in the maternity ward and in the nursery, especially when a boat goes by.

The odors are noticeable chiefly in the summer. They are worse at night or in the early morning and when the weather is sultry or after rains and when boats go through the Canal, stirring it up. A few of the witnesses were not themselves affected, and some of those affected by inability to sleep were not affected by loss of appetite, and vice versa. With very minor exceptions, no one loses any time from work.

Several of the witnesses referred to the fact that hot weather also oppresses people and makes sleeping difficult and affects their appetites.

The patients in rooms on the east side of the hospital adjoining the Canal were more troubled than those on the

other side and some asked to be transferred, but not all did so. The odors have a worse effect upon new patients, those with delicate stomachs or very sick patients. Some patients are not susceptible.

One of the Sisters who entered the hospital in 1917, testified that the odor from the Canal had always been very offensive. Another Sister who came to Joliet first in 1910, said: "Well, whenever there was an odor, we would say to each other, 'What is the smell?' 'It is the old dirty Canal.'"

The average period of stay in St. Joseph's Hospital during 1939 was about one day less than the average for general hospitals in the country as shown by the records of the American Hospital Association.

Testimony of Principal Civilian Assistant to United States District Engineer

Mr. C. R. Andrew, the principal civilian assistant of the United States District Engineer at Chicago, has worked along the Illinois Waterway continuously since 1925. He testified that prior to the building of the locks in the Illinois River, there were concentrations of pollution at Lake Joliet, which is a short distance below Brandon Road and also at the old Marseilles Dam and Peoria Lake, which are, respectively, about 50 and 120 miles below Joliet. He was first located in 1925 at Starved Rock Lake, (about 60 miles below Joliet). At that time the odors from the river at that point and at the old Marseilles Dam were extremely offensive. The odors in Joliet at that time were also very offensive. Conditions had improved greatly in 1930. In 1933, when the dams were put into operation, the water continued to improve year by year, and from 1933 to 1938, generally speaking, there was no nuisance of any kind, that is no odors except at times when the water was shaken

up with a strong wind, and close by the dam where you got the spray. In 1939 the conditions in Joliet were considerably worse than in 1938. In 1925 up to 1932 the water at Joliet flowed rapidly over rocks and the odor was much worse than when the water was quiescent. It was the witness' opinion that the odor conditions in Joliet in 1925 and 1939 were about the same. Summarizing, up to 1925, the conditions were very bad; from 1925 to 1938, they were improving and in 1938 they were the best they had ever been; in 1939 they were worse. The witness had made comparatively few trips in 1940, but thought 1940 was not as bad as 1939.

At my request, Mr. Andrew compiled figures as to the number of sick leave absences during the years 1938, 1939 and 1940 of the employees of the United States Engineers employed along the Waterway in the Joliet area, which covers a stretch of about 60 miles from Lockport to Starved Rock and in which during the 3-year period there was an average of about 170 employees. In accordance with my suggestion, Mr. Andrew included in the tabulation for comparative purposes similar data with respect to the employees in the Chicago, Peoria and Calumet Harbor areas. The tabulation showed that the percentage of days absent on such leave to total work days sick leave in the Joliet area in the three years in question was 4.34, which was practically the same as in the other areas, except in Peoria where the percentage was slightly under 3. The percentage of sick leave days in 1939 was higher than in 1938 in all areas except Peoria, but the 1939 percentage for Joliet was slightly less than for the Chicago District Office (which includes office employees). The sick leave absences were also slightly less in the Joliet area in 1939 than in the area known as Calumet Harbor and Blue Island, which covers sections of the Waterway north of

Lockport, from which there was no proof of any complaint of conditions along the Waterway. In 1940 the percentage of sick leave absences was slightly more in the Joliet area than in the Calumet Harbor and Blue Island area, but substantially less than in the District Office area. The percentage of sick leave absences in the Joliet area in 1940 was substantially less than in 1939.

The total number of men employed on non-government craft moving over the Waterway through Brandon Road was estimated at 75 to 100. Only one person employed on any boat appeared before me as a witness; he was the pilot above referred to. There was no suggestion from any quarter that nuisance conditions at Joliet and Lockport or elsewhere along the Waterway had interfered with or impeded navigation.

Testimony of Physicians at Joliet

Fifteen physicians residing in Joliet, including the Health Commissioner of the City, testified before me.

The Health Commissioner testified to receiving hundreds of complaints in June, July and August, 1939. These were from persons who resided not far from the banks of the Canal. He personally had not observed any evidence of temporary illness resulting from the odor, but in his opinion there was danger of an epidemic by flies and mosquitoes lighting on the scum and carrying away germs which might mean dysentery or typhoid fever. "The stench is nerve-wracking and by producing nausea, loss of sleep and loss of appetite might bring on a condition of degeneration." Gases from the odor may set up irritation of the mucous membrance of the nose, throat and sinus. However, the health conditions in Joliet are "very good, very." They were not any worse in 1940 or 1939 than in 1938. "The only difference in the canal is the odor. That is all."

The testimony of the other doctors was substantially to the same effect. In general terms they all considered the Canal a menace to health for the reasons given by the Health Commissioner. One of them suggested that germs from the Waterway might be blown through the breeze. Another thought the Canal might be responsible for streptococcic sore throat. Another thought sinus trouble might be due to it. One of the physicians testified he was a government surgeon and took care of the men working on the Canal for the government and had many cases of skin diseases, making it necessary to take them off their jobs for a while, attributable to the foul water they came in contact with.[1] This witness testified:

> "I must honestly state that I don't believe it is a menace to the health of the average healthy individual, but it certainly is a menace to the health of the individual who is not strong and is ill from other causes. It certainly shortens their life. It menaces their after-health in every way. It can't help but do it."

No cases of specific illness clearly attributable to the Canal were cited by the physicians. The few cases to which they referred were chiefly of persons ill from other causes whose illness was thought by them to be aggravated by the odors from the Canal.

The Joliet city chemist and bacteriologist testified that samples of the water in the Canal taken in June, 1940, showed bacilli coli ranging from a low of 10,000 per c.c. to a high of 40,000 per c.c. No tests or analyses were made in earlier years. United States Public Health standards for potable water permits presence of 1 bacillus coli in 100 c.c. Joliet is situated on a limestone bed. The

[1] On this point the testimony does not seem to be supported by the statistics of the office of the United States Engineers at Chicago hereinbefore referred to.

fact that the Waterway was constructed by blasting led the witness to believe that fissures have been created in the rock, through which it would be possible that water might leak into wells. If the flow were increased to 5,000 c.f.s., there would still be a source of contamination from the water, although the danger would be reduced; it would not be possible to sterilize the Waterway so as to kill all the B. coli in it. Joliet gets its water from two deep wells, which are not in close proximity to the Waterway. The water from them is as safe as any water can be. All requirements of the State Health Department have been met. If the city needed more water, it could build more wells at a safe distance from the Waterway. It would be correct to say that there had always been a potential menace with sewage carried in an open Canal like this and theoretically it is very undesirable.

Health Statistics of Joliet

The annual reports of the Illinois Department of Public Health show, with respect to certain communicable diseases, the number of cases and deaths in Joliet, Will County (in which Joliet and Lockport are situated) and other counties in Illinois. The diseases reported upon are diphtheria, encephalitis, influenza, malaria, measles, menengitis, pneumonia, poliomyelitis, scarlet fever, smallpox, tuberculosis, typhoid fever and whooping cough. In 1939 the rate of reported cases per 100,000 inhabitants was less in Wills County than the average for the State of Illinois as to every one of the enumerated diseases except poliomyelitis, malaria and influenza. In 1939 the death rate was lower in Will County with respect to every one of the diseases than the average death rate for the State as a whole.

In 1939 the typhoid case rate per 100,000 inhabitants for Will County was 7.3 while the rate for the State as a

whole was 11.9. In the 9 years from 1930 to 1938 typhoid cases in Will County were at the rate of 19.1 per 100,000, whereas in 1939 the rate had declined to 7.3. The typhoid case rate in Will County was less in 1939 than in any year beginning with 1930 except in 1938, when it was 6.4. The typhoid death rate in Will County in 1939 was .9 per 100,000 inhabitants as compared with an average of 1.8 for the years 1930 to 1938, and a rate of 1.4 for the State as a whole.

With respect to Joliet proper, no separate evidence was offered as to rates of typhoid cases and deaths, but proof was offered as to the number of typhoid cases and deaths in Joliet from 1930 through 1938 and also as to the number of cases in 1939. There were 9 reported typhoid cases in Joliet in 1939 as compared with 1 in 1938, 10 in 1937, 11 in 1936, 10 in 1935 and as many as 20 in 1930. There appear to have been no typhoid deaths in Joliet since 1936, when there were 3; in 1933 there were as many as 7.

A comparison of rates of reported typhoid cases and deaths per hundred thousand population in (a) 22 Illinois counties adjoining the Waterway and (b) 80 counties not adjoining the Waterway, shows the following:

Rate Per Hundred Thousand Population of Reported Typhoid Cases and Deaths

	Counties Adjoining Waterway		Counties Not Adjoining Waterway	
	Cases	Deaths	Cases	Deaths
Average from 1923 through 1939		0.9		3.9
Year 1939	2.9	0.4	12.0	3.1
Year 1938	4.1	0.4	11.5	1.4
Year 1937	3.3	0.4	13.4	1.5

Testimony from Residents of Lockport

Lockport is a small community located about four miles north of Joliet. Its population in 1930 was 3,383; in 1940 it was 3,433. Four of its residents appeared

before me. They included the Mayor, the secretary of the Chamber of Commerce, the superintendent of a grade school and an employee of the Texas Company. Testimony was also given by the engineer of an oil plant situated between Lemont and Romeo, some distance above Lockport. In addition, I took the testimony of two government employees residing at Lockport.

The Mayor of Lockport testified that he had had numerous complaints of odors, but knew of only one resident leaving Lockport because of conditions and this was a family which lived "very, very close" to the Canal bank. The secretary of the Chamber of Commerce testified that the Canal had always been a source of complaint as they had always objected to it being "a cesspool for the City of Chicago or any other territory". Odors at Lockport from the Texas Company's oil refinery are, he said, "slightly disagreeable, but not intense".

An employee of the Texas Company who had lived in Lockport 35 years and was a former Mayor, testified that conditions in the warm months of 1939 were 'terrible", due to the very bad odor. There was no current and there was a lot of sludge on top of the water. Asked what effect the odors had upon the people, he said:

> "Well, not very pleasant * * * I would not say it actually made them sick. It was not very pleasant to breathe. * * * You could not sleep when it was working real good. * * * The only way you could sleep was by closing the windows."

The superintendent of grade schools at Lockport testified that during April and May of 1939, children had to be sent home "because they were sick to their stomachs, had headaches and threw up at school; some of them had dysentery. They were absent just a day or two". Also in May, 1940, as many as 10 or 12 children would be

absent, just for a day, with nausea and dysentery. The witness said that the odors did not affect her ability to sleep, but "it was very disagreeable—it would be very much nicer to have fresh country air".

The chief engineer of the Globe Oil Company, which has a plant situated about 3½ miles out of Lemont, some distance above Lockport, testified that his company takes water out of the Canal for cooling condensing equipment and its men have to clean the sediment out of condenser boxes. Some of the men doing this work have to lie down, sick and blue, and have to be sent home. Men with open sores who have come in contact with the water have had infections. His plant gives off a malodorous odor to one who is not accustomed to it, but people who know the plant is there get accustomed to it.

Master's Inspection of Conditions at Joliet and Lockport

On Monday, July 8th, 1940, I went from Chicago to Joliet by automobile and we took a boat below the Brandon Road Dam and proceeded to the Lockport Dam. On that day at Joliet the maximum temperature was 88° and the minimum temperature 65°. I did not at that time observe any very offensive odor.

On July 23, 1940, after the adjournment of the hearings at approximately 6 P. M., I visited the Lockport Grade School of Lockport, accompanied by counsel and the court reporter. At 6:25 P. M. it was 92° in the shade on a wall thermometer in the school. I noted that at that time there was no perceptible odor in the office of the principal, that the day was very hot and there was no breeze in motion.

From the school I went to the 9th Street Bridge in Lockport leading across the Canal, which was about 3/4ths of a mile from the Lockport Grade School. I

walked across the bridge with counsel and noted that there was a very slight odor with a good breeze from the Southwest and a perceptible current. I observed some scum floating down which contained also logs and sticks of wood and was apparently only on the surface of the water. There seemed to be a greasy, oily substance on the surface of the water. I noted a perceptible odor along the wall of the Canal, which appeared to me slight.

I then proceeded in an automobile on the road along the side of the Canal to the Lockport lock. Driving along the Canal I noted a slight odor. Arriving at the lock there was a good breeze blowing, but I could observe very little odor, notwithstanding the water was dammed at this point.

At the lock I found the United States Lockmaster, Edward P. Callaghan, whose testimony I took.

Mr. Callaghan has been employed as Lockmaster continuously since 1932. In 1930 he painted the towers adjoining the dam. He said:

> " * * * At that time the water out there was so thick you could almost paint with it. * * * We almost had to get clothes pins to put on our nose. * * * Conditions are nowheres near as bad as they were then. They have been clearing up that water. Cleared it up, I would guess, at least 60%."

The odors have not affected his health nor that of his wife or of his grandchildren who visited him recently in the summer.

I also took the testimony of the Lock Mate. He thought conditions better in 1940 than in 1939. His family, wife and daughter, live about three-fourths of a mile away and had suffered no ill effects. He thought you got used to the odor. He had fallen into the water

several times and suffered no effect. A young woman who had fallen in it had also been pulled out without ill effects.

On Wednesday, July 24th at 7:30 P. M. I took a speedboat above the Jackson Street Bridge at Joliet. I was accompanied by counsel for the opposing States and by two employees of the Illinois Waterway Division. The attorneys for Illinois were unable to attend because of conferences with witnesses. I dictated my impressions to the court reporter as we went along. We proceeded under the bridges crossing the Waterway at Cass, Jefferson and McDonough streets, through the Pool to the Brandon Road Dam. We then turned about and proceeded north to the Lockport lock, which we reached at 8:30 P. M. We then turned back to Joliet, which we reached at 9 P. M. The thermometer outside the hotel at this hour registered 92°.

My notes show that in this inspection trip I could detect an odor from time to time but only intermittently; it would last for a few seconds or a minute and then I would lose it for several minutes and then catch it again. It seemed to be more noticeable as I came under bridges, and it was suggested by one of the Waterway representatives that the odor would have been more noticeable if we had stayed along the walls continuously than it was in the middle of the stream. While it was perceptible, it did not seem to me terrible or particularly bad at any time. I noted that it would not bother me very much, although it might bother others and I would not call it pleasant, although it was not strong. It did not seem to be any worse at the wider section of the Pool than at other points. I did not observe any flies and had only one mosquito bite, although it was dusk. At times there was a good breeze, which at other times died out. I saw a

number of bubbles on the water, which I was told represented operation of gas from sludge underneath the surface. At first I saw little scum. Then as we proceeded I saw along the walls a rather thick surface layer, which appeared to be scum and which contained pieces of wood, paper, miscellaneous debris and a good many grease spots, which might have been due to oil. This scum varied in extent at different points. At one point it was 2 or 3 feet in width; at others perhaps 10 to 20 feet; it was usually on the side along the walls, but I observed it also at points in the middle of the Waterway. Bubbles were apparent for the whole width of the Waterway. At one point I detected an oily odor.

After returning from this inspection trip I noted at 11:30 P. M. in my room at the hotel (which was about 4 blocks from the Waterway) an odor which lasted a minute or two; a few minutes later I got another odor for a minute or two, and then detected no more odors. I slept four nights at Joliet and was not troubled by odors. The only trouble I had in sleeping was due to the heat, which was so great that I kept an electric fan constantly going all night. The City Hall, in which the hearings were held, was about three blocks from the Canal on the east side; I detected an odor only on one day and then only for a few minutes. The four days I spent in Joliet were the hottest of the summer, the temperature reaching 103 degrees on July 25th.

Weather Conditions at Joliet in 1939 and 1940

The maximum, minimum and mean temperatures according to government records, at Joliet during the months of May to September, inclusive, in 1939 and 1940 were as follows:

	1939			1940		
	Highest	Lowest	Mean	Highest	Lowest	Mean
April	82	21	46.1	76	23	46.8
May	90	30	63.5	86	28	56.4
June	93	44	72.3	91	40	70.2
July	96	52	73.6	103	43	74.2
August	90	52	71.4	98	45	73
September	100	41	69.2	91	31	63.2

The departures from normal in temperatures at Joliet in the months from May to September in each of the years 1939 and 1940 were as follows:

	1939	1940
April	−2.7	−2.0
May	+3.7	−3.4
June	+3.7	+1.6
July	+0.1	+0.7
August	−0.2	+1.4
September	+4.2	−1.8

Thus, May, June and September were hotter in 1939 than in 1940 while July and August were hotter in 1940 than in 1939. In the four days during which testimony was taken in Joliet (July 22nd to 25th) the maximum temperatures in 1940 were 94, 97, 100 and 103, while minimum temperatures were 75, 70, 65 and 80. On the same days of 1939, the maximum temperatures were 86, 86, 90 and 82 and the minimum temperatures were 60, 61, 63 and 69.

The departures from normal in precipitation at Joliet in the months from April to September in 1939 and 1940 were as follows:

	1939	1940
April	+0.26	+0.17
May	−1.89	+0.51
June	+5.03	−1.03
July	−0.81	−3.08
August	−1.38	+2.92
September	−3.09	−3.38

In the chemical processes which are responsible for the development of gases and odors, the temperature of the water is controlling, not the temperature of the air. It was testified that actual sulphate decomposition does not occur when the temperature of the water falls below 62° Fahrenheit. The mean temperature of the water at Lockport in the months from April to September, in the years 1939 and 1940, according to the Sanitary District records, was as follows:

	1939	1940
April	56	50
May	64	58
June	71	70
July	76	74
August	77	73
September	75	72

Thus, water temperature was lower at Lockport in 1940 than in 1939 in each of the summer months.[1] It seems clear, however, that the susceptibility of human beings to annoyance from odors increases with higher temperature of the air.

Discharges of Sewage and Oil into Waterway Between Chicago and Joliet

The Texas Company has an oil refinery at Lockport which discharges its waste into the Canal two miles below Lockport. The oil refinery odors are "slightly disagreeable, not intense". The waste from the refinery contributes to the oily appearance of the surface of the water below Lockport. A number of the witnesses testified to detecting the odor of oil along the Waterway, and it appears that scum and grease on the surface of the Waterway are due in part to discharges of waste from the oil refinery.

[1]The records of the Sanitary District indicate that the water temperature was higher at Lockport in 1939 than in many years.

Lockport, with a population of about 3,500, empties its sewage into the Waterway below the locks.

The old Illinois State prison outside of Joliet and the new Illinois State prison at Stateville, about two miles north of Joliet, discharge their sewage into the Waterway. These two prisons have an aggregate population of about 6,400, which includes inmates and employees.

Lemont, a town of about 2,500 people, situated in Cook County above Lockport, empties its sewage into the main channel of the Waterway.

The City of Joliet, with a population of about 42,000 discharges its sewage into the Waterway below the Brandon Road Dam. Various small communities above Lockport, including Lemont with a population of about 2,500 people, Argo and Summit, also discharge this raw sewage into the Waterway.

Objections to Increased Diversion by Illinois Communities Below Joliet

Four witnesses who were not subpoenaed by any of the parties appeared before me and asked to be heard. These were George P. Moore, Thomas H. Detweiller, Dr. J. P. Kerr and Harry F. Goodell.

Messrs. Moore and Detweiller reside at Peoria, which has a population of about 105,000 and is situated on the Waterway about 120 miles below Joliet. Mr. Moore is Secretary of the Pleasure Driveway and Park District of Peoria, and Mr. Detweiller is a Park Trustee at Peoria. They objected to any increase in the diversion from Lake Michigan on the ground that it might bring more sewage down to Peoria. Sewage has been coming down the Waterway for thirty years, but conditions have materially improved in recent years. Fish life has begun to reappear

and offensive odors formerly present have been absent in the last year or two.

The testimony of Dr. Kerr was along the same lines. He is President of the Association of the Drainage & Levee Districts of Illinois, comprising people owning property and farms in the Illinois River Valley. He has represented these people for twenty years and has constantly opposed the introduction of sewage into the Illinois River or increased diversion from the Lake. His Association has adopted resolutions urging that increased diversion be not permitted. He testified that in former years "great islands of floating untreated sewage" were discernible all the way down from Joliet through Marseilles, Ottawa and Peru and even down to Peoria. Particles of untreated sewage were discovered on the surface of the water at Peoria, and conditions were indescribably worse than at Joliet today. Bathing in the Waterway is now practised all the way up to Peoria, when it was formerly not possible. Peoria treats its sewage, but other towns along the river as far down as Beardstown empty their sewage into the river.

Mr. Goodell is a graduate in civil engineering of the University of Illinois and is employed by eleven Drainage and Levee Districts in southern Illinois Counties. He resides at Beardstown, a town of about 6,000 population, situated about 80 miles downstream from Peoria and about 200 miles from Lockport by river. He began to work and live on the river in 1918. The river was polluted then and there seemed to be more or less of a boil in it. People were advised not to swim in it although they did occasionally. During the year 1930 there was a great improvement of the water conditions and fish life has returned. While the water condition in Beardstown is now much improved and there are bathing

beaches, they do not meet the requirements of the Public Health Department. In his opinion, conditions at Joliet are no worse than they were during the '20's and may be better. He had worked upon and in streams polluted by sewage giving off highly offensive odors, but he never observed any ill effects, although the pollution was sufficient to discolor the paint on houses situated near the streams. Peoria formerly discharged its sewage into the Waterway but has recently completed a treatment plant. The Illinois River during past years has been a menace to the health of the residents of areas tributary thereto and is still a menace to those residents notwithstanding the improvement. It would be practicable to periodically flush the Brandon Road Pool, and he did not think that the organizations which he represented would offer any objection thereto as material from the Pool would be fairly well decomposed when it passed Starved Rock, but they objected to increased diversion from the lake which might bring down fresh sewage.

Expert Testimony as to Health Conditions

On August 3, 1940, Willard L. Bergman, a chemist employed at Rush Medical College, at the request of the opposing States, made tests for hydrogen sulphide (1) under the Ninth Street bridge in Lockport and (2) alongside the Jackson Street bridge in Joliet. In each case he took a 3-gallon sample of air. These tests disclosed no trace of hydrogen sulphide. He discerned no odors except one of lubricating oil. The temperature was about 90° or so.[1]

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[1]The methods employed by Dr. Bergman were criticized as inadequate by Dr. Clarence W. Muehlberger, a toxicologist, who testified for Illinois.

On July 16, 1940, tests to determine bacteria in the air in the vicinity of the Sanitary Canal from Lockport to Joliet were made by Dr. Josiah J. Moore and Robert C. Jenkins, a clinical laboratory technician. Dr. Moore is a graduate of the University of Chicago and Rush Medical College, has taught bacteriology and pathology at the University of Illinois and is pathologist for several hospitals. The tests were made at ten locations along the banks of the Canal, six locations about seven miles west and six locations about four miles east. The tests showed no pathogenic bacteria present at any of the locations. The bacteria found were the usual bacteria one might find in air at any place. Dr. Moore testified that germs and bacteria present in scum on the surface of the Waterway or along the sides of banks or walls could not be blown through the air in such a way to cause a hazard producing disease to people along the Waterway. It would not be possible for an epidemic to break out in a community adjoining the Waterway by the transmission of germs or bacteria by air. In the opinion of Dr. Moore, based upon his analysis of the air, there was no danger to the health of people along the Waterway. He testified that there is no basis for any suggestion that germs from the water might cause streptococcic infection in the throat without drinking the water; you could not get a streptococcic sore throat by living along the banks of the Canal and breathing the air. Disease could be contracted only by eating food contaminated by germs carried by flies or other insects. Flies usually alight only on solid material. If insects had gotten on the culture plates, that would have been shown. In only one case was there a form of insect shown on the plate, and this was away from the Pool. The presence of B. coli in the Canal indicates presence of fecal material, but would not indicate pathogenic bac-

teria. Even the smallest amount of B. coli in water makes it unfit for human consumption.[1]

The testimony of Dr. Moore was confirmed by that of Dr. Norbert R. Enzer, Director of Laboratories at Mt. Sinai Hospital, a graduate in medicine of McGill University. In his opinion any bacteria that may be in the scum formed from sewage are not the bacteria with pathogenic qualities; these have been destroyed long since.[2] Flies lighting on the surface of that water would not pick up anything very damaging to carry away and deposit on people's food or hands. Flies ordinarily alight on dry surfaces, not wet ones; there are many thousands of times more flies on a refuse or garbage heap than on the surface of a stagnant pool. If it could be assumed that the Waterway presented a menace, increasing the flow to 5,000 c.f.s. would not change it.

Testimony substantially to the same effect was given by Drs. James E. Perkins, Edward R. Krumbiegel and Edwin B. Gute. Dr. Perkins holds the degrees of Master of Public Health and Doctor of Public Health from the Johns Hopkins School of Hygiene and Public Health and is Director of the Division of Communicable Diseases of the New York State Department of Health. Dr. Krumbiegel holds the degree of M. D. from Marquette

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[1]Mr. Langdon Pearse, Sanitary Engineer of the District, testified that since the water in the Canal was not used for drinking, he did not concern himself with B. coli figures. He said, "Our work primarily is not concerned with destroying bacteria. As I have said, we want them in the stream, such as they are, to help us do the work of self-purification."

Compare *Missouri vs. Illinois*, 200 U. S. 496, where the court said at page 525:

> "It seems to be conceded that the purification of the Illinois by the large dilution from Lake Michigan (nine parts or more in ten) would increase the danger, as it now generally is believed that the bacteria of decay, the saprophytes, which flourish in stagnant pools, destroy the pathogenic germs."

[2]The Joliet city chemist and bacteriologist testified that the scum was acted on by the sun, which was germicidal to a certain degree, and in his opinion the scum was less likely to contain organisms than the water under the scum.

University and is Commissioner of Health for Milwaukee. Dr. Gute is a graduate of Rush Medical School, Commissioner of Health for the Villages of White Fish Bay and Fox Point, Wis., and Chairman of the Milwaukee County Association of Suburban Health Commissioners.

On September 17, 1940, an examination of the bacterial content of the air at (1) points in Joliet and Lockport both along the Waterway and removed therefrom and (2) points in other Illinois towns a considerable distance from the Waterway, was made by Dr. M. Starr Nichols. Dr. Nichols is professor of sanitary chemistry at the University of Wisconsin, and is employed by the Wisconsin State Board of Health as chemist and bacteriologist, specializing in sewage chemistry; he is the author of numerous papers. He testified that the number of bacteria found at the locks at Brandon Road and Lockport were only approximately 1/10th as many as those found at the other stations. Otherwise there was no remarkable difference between the number of bacteria in Joliet and those at other points. No attempt was made to isolate any pathogenic organisms or to identify the species of bacteria. Typhoid germs are destroyed more quickly in polluted water than in pure water.

On September 17, 1940, Dr. Nichols also examined scum taken from the Canal walls at Brandon Lock and from the Waterway near the lock, also below the Texas Oil Refinery at Lockport. In all of these samples oil-like material was found. On September 28, 1940, he took samples of water from the Canal at the Brandon Locks below the Jefferson Street bridge in Joliet and at the Lockport Lock and tested them for hydrogen sulphide. They showed 0.1 and 0.2 parts per million.[1] The temperature in Joliet that day ranged from 34° to 74°.

[1]No tests for hydrogen sulphide in the area above the waters of the Canal have been made by the Sanitary District.

Testimony as to the effect of hydrogen sulphide in the air was given for the opposing States by Drs. Nichols, Enzer, Krumbiegel, Gute ,and Perkins, and also, particularly, by Dr. Wm. H. McNally.

Dr. McNally is a toxicologist, a graduate of Rush Medical College and a member of its faculty, and the author of two books and a large number of articles on Toxicology. He testified that nausea can be produced in many individuals with as low a concentration as 50 p.p.m. of hydrogen sulphide in the air. A concentration of 100 p.p.m. might cause local irritation and depression of the nervous system; he did not think it would be possible to get such a concentration in the open air from a stream polluted with sewage wastes. A concentration as small as 25 p.p.m. might cause discoloration of paint, which is the most delicate test there is. Alice Hamilton and Drinker of Boston believe that not more than 20 p.p.m. should be tolerated in industry and this is the figure adopted by the Massachusetts code. One would have to be right over floating particles of sewage to get a concentration of 100 p.p.m. When you get 500 or 1,000 feet away from the Waterway, the concentration of hydrogen sulphide would be diluted many thousand times. Some people are more sensitive than others to the smell of hydrogen sulphide. Also one may become accustomed to the odor. In the literature of toxicology there is no recorded instance of damage to health from hydrogen sulphide in a waterway like the Illinois Waterway.

The testimony of the other witnesses for the opposing States was substantially to the same effect. These witnesses included all the doctors above named and also Messrs. Louis F. Warrick and Louis R. Howson, sani-

tary experts. Mr. Warrick holds the degree of Master of Science from Cornell University and is the State Sanitary Engineer of Wisconsin. Mr. Howson is a consulting sanitary engineer who has specialized in sewage treatment work.

All the physicians, health authorities and sanitary experts who appeared as witnesses for the opposing States—nine in all—testified that it was their opinion that the Waterway did not constitute any menace to the health of persons living along it. This opinion was also shared by Mr. Joseph W. Ellms, Commissioner of the Division of Sewage Disposal of the City of Cleveland, Ohio. Mr. Ellms testified that upon his visit to the Brandon Road Pool, it appeared to him to be in better shape than the Cuyahoga River.[1]

Testimony for Illinois on the particular question of the effect of hydrogen sulphide was given by Dr. Clarence W. Muehlberger, a graduate of the Armour Institute of Technology and of the University of Wisconsin, holding degrees of Master of Science and Doctor of Philosophy. He is a lecturer on Toxicology in the medical schools of the Universities of Chicago, Illinois, Loyola and Northwestern and the author of a chapter in Dr. McNally's book on Toxicology. He

[1]It appears from the testimony of Mr. Ellms that the Cuyahoga River, which is 300 to 400 feet wide, and perhaps wider, and has a very low velocity, is grossly polluted by sewage and industrial waste from oil refineries for a distance of about 10 or 12 miles in the metropolitan district of Cleveland. A nuisance condition obtains there today and has obtained there for many years. For a distance of 9 miles, no dissolved oxygen was found in the water in samples taken by Mr. Ellms in September, 1940. Mr. Ellms testified that the Cuyahoga River is a foul stream (although he did not think the odors "are so particularly noticeable") but he did not consider it as a health menace unless people insisted on bathing in it. Nor did he consider the Sanitary Canal a health menace as long as it was not used for drinking or for bathing.

It appears also that the Ohio River is grossly polluted during six months of the average year; see 104 Transactions of the American Society of Civil Engineers (1939) p. 873.

had read the transcript of the testimony of the Joliet witnesses and was of the opinion that the nausea, headaches, insomnia and loss of appetite of which they complained "may have been caused by hydrogen sulphide". He could not refer to any case recorded in medical literature of any individual having been overcome in the open from the air from a waterway polluted by untreated or partially treated sewage. He had no idea how fast the gas might be diluted in the air; it would depend on how strong the breeze was and how fast the gas was coming off the Canal. To the average person the symptoms produced by exposure to over 20 p.p.m. but under 50 p.p.m. would be irritation of the mucous surfaces of the eyes, nose and throat. Some persons are more susceptible than others. Decomposing sewage gives off organic sulphide compounds, including indol, skatol, mercaptans and cadavrin, all having offensive odors. The intensity of odor is an unreliable test of gas present, especially hydrogen sulphide, because the nerve ends in the nose become paralyzed by use. In his opinion the conditions surrounding the Waterway constitute "a very definite menace" to the health of the people of the region of Joliet. People have not died or been rendered so ill as to require hospital treatment necessary but "they might have been rendered very uncomfortable and very unhappy". "I believe that people are entitled to a decent place to live, comfortable surroundings where the air that they breathe is perfectly good, healthy air, and I believe that anything that can be overcome which contaminates the air so that they aren't in a good, sound state of health, is a menace."

Dr. Muehlberger testified that the odor of the Canal in 1939 had irritated his throat and nasal passages. He knew that the Waterway prior to 1939 always gave off

odors, especially in summer, but would not say that he had ever noticed this irritation before.

The principal witness on the health issue for Illinois was Dr. Anton J. Carlson. Dr. Carlson received the degree of Doctor of Philosophy in physiology from Stanford University in 1903 and the degree of Doctor of Medicine from the University of Lund in 1917. He has never practiced medicine privately, but has trained over 5,000 doctors. Since 1904 he has been on the medical faculty of the University of Chicago and for the last twenty-five years has been professor and chairman of the department of physiology in that university. He is a member and officer of many medical and scientific societies, a member of the Public Advisory Committee of the United States Public Health Service and a consultant to that service, advisor of the Department of Public Health of Chicago, and for the last twenty-five years Chairman of the Public Health Committee of the City Club of Chicago.

Dr. Carlson inspected the Waterway on October 13th, 1940, and had read much of the testimony given at Joliet. He testified that in his opinion "the present condition is more than a menace to health; it is inimical to health". Asked what factors he would consider in determining what constituted an actual menace to health, he answered:

> "Why, an actual menace to health to me means that conditions exist in that pool that through accidents or any ordinary course of human events in the district can lead to health injury—injury to health. We don't have to prove actual injury to health. We have got to prove that conditions exist there which, through accidents or any ordinary course of human events, business and life, may result in injury to health".

Dr. Carlson further indicated his view that there was also an actual menace from dysentery bacilli, from typhoid bacilli and from the amoeba of dysentery.

> " * * * the water doesn't have to be used for drinking or cooking to constitute such a menace, and it doesn't have to occur either for 10, 15, or 5 years. It is still a menace. * * * the highly polluted body of water may through accident, through flies or mosquitoes, or spray or wind get on the surface of man, on his clothes, on his skin, or in his food, or even in his drinking water, even in his lunch pail, and anything—we know anything that gets on our skin anywhere— * * * flies don't have to bite, mosquitoes don't have to bite, they don't have to settle on the water. This stuff splashes up on the sides when the boats go through, when they empty their locks and fill them and when the wind blows. Such a polluted, highly infectious body of water of that extent is an actual menace, if I have made my answer clear."

Dr. Carlson testified that the fact that the present communicable disease rate in Joliet is no higher than in other places is no factor whatever in determining whether the Canal is a menace to health. Either they have been lucky or the medical statistics are not what they are supposed to be. It is unimportant that the water is not used for drinking purposes or bathing. "People will drop in by accident and the children will jump in by choice, no matter what you say". Bacteria can reach them by flies and mosquitoes carrying this stuff mechanically and "under extreme conditions might reach them if they walk close by the Canal in a spray in a high wind."

Dr. Carlson has been familiar with the Waterway for many years. It has constituted a menace to health since 1934, but now it has been increased. He agreed

that when he used the words "menace to health" he was using them in a scientific sense as a theoretical danger which cannot be measured in any statistics or even in any outward observation by a physician.

> "The policy that guides us and you and the courts is to take all measures to minimize all these, any or all of these unfavorable conditions, that we can do within the practicability of our knowledge and our civilization. * * * The amount of water asked for by the State of Illinois, temporarily or even during the summer, could not conceivably have any health significance for the other States, and I think it insignificant and uneconomic."

Dr. Carlson agreed that if the diversion from Lake Michigan were restored to 5,000 c.f.s., there would still be a menace to health, but, he said, it would be less. He also agreed that carbon monoxide in Chicago from automobiles is a constant detriment to the health of the people in Chicago.

Testimony substantially to the same effect was given by Dr. Carlson's associate, Dr. Andrew C. Ivy, who holds degrees of Bachelor of Science, Master of Science and Doctor of Philosophy from the University of Chicago and the degree of Doctor of Medicine from Rush Medical College. Dr. Ivy has taught physiology and pharmacology at the Medical Schools of Loyola, University of Chicago and Northwestern University. He is President of the American Physiological Society and the American Gastro-interiological Society, and a member of the Public Health Committee of the City Club of Chicago, and has had occasion to study questions relating to sewage disposal, procural of water from Lake Michigan, and water pollution. He had visited the Waterway with Dr. Carlson and read the transcript of testimony given at Joliet. The testi-

mony that the odor had caused nausea, disturbances of appetite and sleep, showed, in his opinion, an unhygienic condition working as a detriment to the health of the people that the odor so affects. This would be particularly true of children with poor appetites, convalescent patients in a hospital and invalids. He considered that the Brandon Road Pool and the Sanitary District Canal constitute an actual menace to the health of the community of Joliet. He explained his answer by saying:

> "I am convinced of the truth of the dictum or general principle that pollution of the air or streams is unhygienic, or unhealthful, and that they should be abated, if possible. All the time or continuously in society we are trying to improve unhygienic conditions of living because we regard them as being unhealthful. We abate smoke; we abate noise; we abate dust; we try to abate pollen distribution because of the hayfever sufferers; we abate stray dogs because of the threat of rabies and the spread of disease by stray dogs, and when a water supply is even threatened with pollution, there is any question that the water supply might be polluted, we immediately take steps to take care of the situation, and it is on the basis of generalizations and principles of that sort that I believe that there is an actual menace to health existing there now."

Dr. Ivy further testified that diluting the water would not eradicate the menace, but, he said, it would decrease it. Any stream polluted with untreated sewage is a menace to health. Oil odors are at times detrimental to health and should be abated, but they do not affect one psychologically as sewage odors. The odors of stockyards may contain hydrogen sulphide, which should also be abated. Noises in the city such as that caused by the operation of elevated railroads constitute

a menace to health because an unhygienic condition, which should be reduced. Dr. Ivy knew of no recorded case of an individual being overcome by hydrogen sulphide from a waterway. Generally, his testimony was to the same effect as that of Dr. Carlson.

Dr. Hugh Alister McGuigan accompanied Drs. Carlson and Ivy on their visit to the Waterway on October 18th. Dr. McGuigan holds the degree of Ph. D. in physiology and chemistry from the University of Chicago, and the degree of M. D. from Rush Medical College. He was professor of pharmacology at Northwestern University for seven years, and since 1917 has been professor of pharmacology and therapeutics at the College of Medicine of the University of Illinois. He is a member of various professional societies and has written several books on pharmacology. He is not a practising physician though licensed to practise and having some consultations. His field is pharmacology, which deals with the application of drugs to the treatment of disease. He had read or heard the testimony of Drs. Carlson and Ivy and agreed in the main therewith. He added that hydrogen sulphide which had been dwelt on so much was not the only thing in the air adjoining the Waterway. "The cadaverin, putrescin and all the other things mentioned in there, those are positive things, but there are many other things that we don't know anything about in there which may be even more toxic than the hydrogen sulphide. We simply don't know."

No representative of the Illinois Department of Health or any sanitary officer of the State of Illinois appeared before me. The Chief of the Illinois State Waterway Survey, Dr. A. M. Buswell, was placed upon the stand by the opposing States in support of their contentions as to several ameliorating measures,[1] but

[1]Dr. Buswell's testimony is referred to *infra* at pages 84, 96, 97.

gave no testimony with respect to the existence of any health menace.

General Authorities on Sewage Odors

In a report of the Committee on Sewage Disposal of the Public Health Engineering Section of the American Public Health Association, on "Chlorination in Sewage Treatment" (of which Mr. Langdon Pearse was Chairman and Dr. Mohlmann was a member) it is said:

> "A long prevalent theory that sewage odors are directly responsible for disease has been definitely refuted. It is now realized that the physiological effect, if any, is indirect. Odors, by causing worry, loss of sleep, loss of appetite, etc., may be a contributory cause of ill health, and certainly cause discomfort. The courts, in general, have held that the creators of an odor nuisance are responsible therefor, and as far as municipal sewage disposal is concerned, the odor hazard appears to have been shifted from the public health to the public pocketbook."[1]

In his work on Preventive Medicine and Hygiene,[2] Professor Milton J. Rosenau of the Harvard Medical School, says:

> "While odors may be unpleasant, they are not known seriously to influence health; contrary to common opinion, they are not by any means a reliable sign of danger. * * * (p. 898).
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> "The odors from marshes and from decomposing organic matter are not apparently hurtful. One of the most famous stenches that has been recorded, if not the most famous, was that which arose in 1858 and 1859 from the Thames, which

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[1]Report of Committee on Sewage Disposal of the Public Health Engineering Section, on "Chlorination in Sewage Treatment" (1934), p. 30.

[2]See Rosenau, Preventive Medicine and Hygiene, Sixth Edition, (1935) pp. 898, 899, 900, 928.

at that time was grossly polluted with the sewage of London (Sedgwick). It was commonly believed to be the cause of pestilence. Budd insisted that no serious results followed. After giving his proof, Budd states, 'Before these inexorable figures, the illusion of half a century vanished in a moment.' We now know that odors in the air bear no reference to contagion or infection and, however unpleasant, need not be feared as sources of disease. * * * (p. 899).

"The effect of odors upon health is not well understood. When we sense a pleasant smell, we involuntarily take deeper breaths; on the other hand, unpleasant odors tend to diminish the respiratory exchange. Odors influence the nervous system in various ways; some stimulate, others depress psychic activity. Some odors have a well known influence upon sexuality. Occasionally, odors are so disagreeable that they induce nausea, even vomiting. It is remarkable how quickly we may become accustomed to odors, but the fact that our sense of smell has been dulled is no guarantee that the cause of the odors may not continue to produce its effects. * * * Winslow and Palmer found that 'odors' of vitiated air have an unfavorable influence upon appetite." (p. 900).

"Sewage gas, once a hygienic bugaboo, is now not seriously regarded by sanitarians. Sewer gas became the residual legatee of Murchison's pathogenic theory, namely, that typhoid fever was 'produced by emanations from decaying organic matter.' People naturally cling to the notion that anything that smells bad must be detrimental to health. Sanitarians know, however, that our sense of smell is a poor sanitary guide." * * * (p. 928).

Condition of Waterway in Earlier Years

In considering the weight to be given to the claims of Illinois that the situation in Joliet and Lockport pre-

sents a menace to health which makes imperative an increase in the diversion, it seems pertinent to consider the situation which has prevailed in past years.

The Waterway has always been a polluted stream due to the discharge of untreated sewage from Chicago. It appears from the first (1927) report of Special Master Hughes, quoted *supra*, pages 6, 7, that the Canal was grossly polluted in 1872, and that in 1891 the nuisance along the Canal was at times as bad as ever. The 1925 report of the Engineering Board of Review of the Sanitary District gives particulars of offensive conditions in 1911, 1912, 1913, 1919 and 1921. In September, 1911, the water of the DesPlaines River at Lockport had a "grayish look and a filthy smell", and its organic contents were evidently in an advanced state of decomposition. In 1919 there was a marked septic action at all points of the river from the head as far as Ottawa (about 60 miles below Joliet). At Morris (about 30 miles below Joliet), "there was considerable scum and there were numerous patches about 12 inches square of semi-solid, black sludge which had the appearance of being 'throw-ups' from the bottom". Seen from a distance as from a bridge, the water had a deep black, foul appearance. At Marseilles (about 50 miles below Joliet),

> "the river had a very bad appearance,—practically covered with black, slimy scum accompanied by very strong septic action. This scum had the appearance of being sludge from the bottom which had been softened and disintegrated. There was a marked septic sewage odor at all points as far as Marseilles, where it was the worst, being very noticeable in the business district of the town, at a distance of a quarter of a mile from the river."

Between Peru and Spring Valley (about 70 miles below Joliet), "the septic action was so violent as to be

fairly boiling, forming a thick scum from shore to shore, with the whole surface covered with patches of sludge from a few inches to 3 feet square."

In 1921 the water in the west arm of the Chicago River was almost black and the surface was covered with a thick scum. In May, 1922, large amounts of dead fish were observed floating on the surface of the stream at Lockport and there was a moderate odor. At Brandon Bridge in 1922 thousands of dead minnows were noted along the margins of the stream, and odors were given off from these dead fish; there was a slight sewage odor.

Mr. Langdon Pearse, Sanitary Engineer of the District, testified before Special Master Hughes in 1927:

> "The condition in the canal and rivers is now bad. It constitutes a condition of nuisance and has been going on for a number of years; in fact, ever since I have been connected with the District there has been a passage of solids from the canal down the rivers lodging behind dams and creating consequent nuisance in the water pools, and the water behind the dams can be smelled for a distance of half a mile. Fish have been driven out of the upper river as far down as Chillicothe, and conditions of odor are noticeable at Chillicothe, a distance, roughly, of 110 miles from Lockport."[1]

Note has already been made of the testimony of Mr. C. R. Andrew, principal civilian assistant to the United States Engineer at Chicago, that conditions in Joliet were as bad in 1925 as in 1939, and of the testimony as to conditions in earlier years at Joliet and points further down the Waterway which was given by Dr. Kerr and Messrs. Moore, Detweiller and Goodell.[2]

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[1]Abstract of evidence on re-reference, page 720.

[2]See *supra*, pages 19, 20, 32-34.

Conclusions as to Health Conditions

I summarize the facts as found by me regarding health conditions as follows:

The present complaints as to the condition of the Waterway are confined to residents of Joliet and Lockport and proceed chiefly from persons living in close proximity to the Canal. Health conditions in Joliet are very good. Fewer communicable diseases exist in counties adjoining the Waterway than in other Illinois counties. The typhoid rates for Will County and the other counties adjoining the Waterway have substantially declined since 1930. The typhoid death rate for Will County in 1939 was not much more than half that for the State as a whole. No water from the Canal is used for drinking. There is no swimming in the Waterway. Germs cannot be blown through the air from the Waterway and, in order for germs in the Canal to cause illness, one would have to drink the water or germs would have to be carried by flies or other insects and brought into contact with food. There is no evidence that flies or other insects have in fact carried any germs which have contaminated food and caused illness. On the contrary, the health statistics indicate that no illness has in fact been caused in this way.

The complaints as to the condition of the Waterway are based entirely upon the very offensive odors given off by it in the summer time and the effect of such odors upon persons living close to the Canal, in causing loss of appetite, nausea (in a few cases vomiting) and inability to sleep or difficulty in sleeping. These odors are due in part to hydrogen sulphide and in part to other unidentifiable gases. The dilution of such gases in the open air is very great. The odors from the Canal are intermittent but extremely unpleasant and disagree-

able to those living in close proximity to the Canal on hot and sultry days and nights in summer, particularly when the water in the Canal is stirred up by boats. Nervous persons or invalids are especially susceptible to the odors. On hot and sultry days school children have been nauseated and caused to lose a day from school. Many persons living alongside the Canal are not affected by the odors and have become accustomed to them, but a substantial number are disturbed by them. Independently of odors, hot and sultry weather makes sleep difficult and affects the appetite.

For many years the Waterway has been an offensive stream containing Chicago sewage wholly untreated or only partly treated. There have always been odors from the stream at Joliet and Lockport. In 1925 when the river at Joliet flowed over rapids in the stream, the odors were very offensive. From 1930 to 1938 conditions at Joliet improved, notwithstanding reductions in the flow from Lake Michigan because of the added treatment which the Chicago sewage gradually received. The people at Joliet had become accustomed to this improvement. When the flow from Lake Michigan was reduced on December 30, 1938, conditions retrogressed and complaints ensued from residents, who compared the 1939 conditions with those prevailing in 1938 and immediately prior thereto. They had either forgotten the conditions prevailing prior to 1930 or, not unnaturally, felt that the improvement should continue. The nuisance conditions in 1939 were much worse than in 1938. They were not as bad in 1940 as in 1939.

The foregoing statement sufficiently discloses the facts as found by me. Whether these facts constitute a "menace to the health" of the inhabitants of the complaining communities within the meaning which the Court

intended that phrase to have, requires a decision as to which I have no certain guide. Counsel have gone to the dictionaries for definitions of menace, but it seems to me beside the point to cite such definitions to the Court which itself used the phrase and will itself determine what it meant. In this report I can only give the phrase the meaning and scope which it seems to me that it was intended to have in this case. I do not believe that the Court intended to use the expression "menace to health" in the sense in which it was employed by Professor Carlson and Professor Ivy. On such a view it would not have been necessary to refer the case to me because it was apparent on the face of the papers that the sewage treatment program of the Sanitary District had not been completed and that untreated and incompletely treated sewage continued to be discharged into the Waterway.[1] Under this condition, if the test is to be that which was urged by Professors Carlson and Ivy, it is clear that a menace would necessarily be found to exist. Accepting this definition the increase of the flow to 5,000 c.f.s. would not eliminate the menace, as these witnesses agreed; the stream would continue a menace within the suggested definition as long as any untreated sewage

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[1]This comment is also applicable to the argument urged upon me by Illinois that the opinion and decree of April 21, 1930, did not contemplate that the diversion should be reduced below 5,000 c.f.s. unless the sewage treatment program which is in contemplation had been completed and the sewage of Chicago treated to the extent of 85%. If this were the view of the Court, there would have been no occasion for a reference to me. It seems to me quite clear that by its opinion and decree of April 3, 1940, the Court intended to announce a final decision that additional diversion should not now be permitted unless shown by convincing evidence to be required by paramount considerations of health.

is discharged into it.[1] It is obvious that the presence of untreated sewage in an open stream is not in accordance with proper standards of sanitation and should be abated. So also, as pointed out by the scientists, should be abated excessive noises in large cities, vibrations from elevated trains, carbon monoxide from automobiles, offensive odors from stockyards and oil plants, and, one might doubtless add, dust, smoke, soot, and other impurities in the air, inadequate milk control and numerous other undesirable conditions present in many communities. The improvement of these conditions is a local responsibility upon which too much emphasis cannot be placed.

The suggestions made by Professors Carlson and Ivy as to possible danger to children swimming in the Waterway without authority and the possibility of water seeping by accident through fissures in the rock to wells from which Joliet obtains its drinking water, present possibilities too remote for consideration. Conclusions must be rested upon consequences reasonably and naturally to be anticipated and not upon mere possibilities. The record leaves no reasonable room for doubt as to the safety of the water supply of Joliet and Lockport. Nor can the effect of odors upon invalids and persons of less than average health be accepted as any test of health

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[1]According to the Sanitary District estimates there will be some incompletely treated sewage going into the Canal even in 1943 and 1944, which years are not included in the present application of Illinois for a modification of the decree of April 21, 1930. Even sewage completely treated by the activated sludge system is not completely sterilized; see Report of Special Master Hughes on re-reference (1929) at p. 30. Even when the Sanitary District program is completed, the water in the Waterway will not be fit to drink.

Apparently it is uncertain whether there may not still be some (though doubtless greatly moderated) nuisance condition in the summer months at Joliet and Lockport even when the Sanitary District treatment plants have been completed. Mr. Pearse testifying in January, 1941, said: "I think we testified in the beginning, and there was very little cross-examination, if any, that we believed the condition would improve in the Pool in '41 and '42 and that after '42 with the equipment that we expect to put in, that the conditions would be as good as our plant and the like could produce; in other words, that they should be relatively free from nuisance down there * * *".

menace; even in cases of private nuisances the test is the effect of the acts complained of upon persons of ordinary sensibilities and in normal health. In the present case it is Illinois itself which is creating the nuisance of which it complains and of which it seeks to be relieved by water which has in effect been adjudged by the Court to belong to the opposing States.

My conclusion is that the facts proven do not establish any menace to the health of the inhabitants of Joliet and Lockport or elsewhere along the Waterway requiring an increase in diversion in water from Lake Michigan. However, as the issue is one which only the Court itself can determine, I necessarily proceed to discuss the other points covered by the order of reference.

IV.

PRESENT STATUS OF SEWAGE TREATMENT BY SANITARY DISTRICT; OUTLOOK FOR SUMMERS OF 1941 AND 1942

Notwithstanding the importance of condensing this report, it seems impossible to discuss adequately the present condition of the Waterway or the various ameliorating measures (other than diversion of water) which have been put forward for consideration, without a statement with respect to the sewage treatment plants of the Sanitary District and the work which they are doing. This in turn requires some explanation of terms used in sewage treatment.

Meaning and Importance of the Terms "Sludge", "B.O.D." and "Dissolved Oxygen"

The term "sludge" as used in sewage discussions means the so-called solids removed from the sewage by sedimentation. These are not solid at all as the layman would understand that term. They contain from 90 to 98 or 99% water, which is

difficult to remove because of the very slimy, greasy nature of the solids. The term "solids" in a chemical sense means undissolved material or material in suspended form. The solids containing organic matter are known as volatile. The term "sludge" as used in this case includes only material settled out in settling tanks. It does not include putrefactive material contained in effluents of incompletely treated sewage from sewage treatment plants. Since October 1, 1940, no more sludge is being deposited into the Waterway, but putrefactive material in suspended solids continues to be deposited in effluents from the plants, particularly from the West Side and Southwest Plants.[1]

The standard test to determine the strength of sewage is the ascertainment of its five day biochemical oxygen demand. This is a chemical test by which samples of sewage are incubated for five days at 20 degrees Centigrade. The loss of oxygen within this period is reported as the five day biochemical demand, abbreviated as 5 day B.O.D.[2] The percentage of reduction of B.O.D. is the test of efficiency of sewage treatment. According to Dr. Mohlman, the removal of settleable solids in Imhoff tanks accomplishes a reduction of from 35 to 45% of the B.O.D., chemical treatment removes 60 to 65% and activated sludge treatment 90 to 93%.

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[1]It appears, however, that in the discussions of the continuing nuisance effect of deposits of "sludge" in past years, the term as used in the record would include incompletely treated sewage which was discharged into the Canal in effluents and formed sludge banks.

[2]Water containing much dissolved oxygen and suitable for drinking may have a slight B.O.D. The evidence in this case shows B.O.D. of water in the mouth of the Chicago River at Lake Michigan in June, 1940, to have been 1.3 p.p.m., although the water contained 9.9 p.p.m. of dissolved oxygen.

The B.O.D. of raw sewage varies according to its strength, ranging in this case, on 1940 averages, from a low of 107 at the Calumet Plant to a high of 193 at the Southwest plant, where the stockyards sewage is received. The 1940 average B.O.D. of the effluents from the treatment plants ranged from a low of 7 at the North Side plant to a high of 64 at the West Side, where the treatment is only by Imhoff tanks.

Special Master Hughes found that the proposed sewage treatment plants of the Sanitary District should attain an annual average of not less than 85% purification of the sewage treated, and that it was probable that the degree of purification would be 90% or more.[1] In fact, on the 1940 performances in all the sewage plants, the weighted average of percent reduction in 5 day B.O.D. was only 67.8, although at the Calumet and North Side plants it was 90.7 and 94.6 respectively; see *infra*, page 62 and table 8 in appendix.

The 5 day B.O.D. indicates the avidity for oxygen. The supply of oxygen contained in a stream to meet this demand is determined by the amount of dissolved oxygen in the water.[2] The relation between B.O.D. and available oxygen is known as the oxygen balance. If the dissolved oxygen is less than the oxygen demand, the water is putrescible. However, so long as dissolved oxygen is present, the water is not actually in a putrefactive state. When the dissolved oxygen is exhausted, putrefaction sets in, accompanied by offensive odors.[3] Mr. Pearse, the Sanitary Engineer of the District, and Dr. Mohlman, its Director of Laboratories, in this case contend that at least 1 p.p.m. of dissolved oxygen is necessary to prevent nuisance; and that is the basis for the modified petition of Illinois (*supra*, page 4). The weight of opinion, however, seems to be that the presence of any dissolved oxygen is sufficient; compare *New York v. New Jersey*, 256 U. S. 296, 311, decided in 1921. In the complete

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[1]Report of Special Master Hughes on re-reference (1929) p. 35.

[2]The dissolved oxygen in Lake Michigan water ranges from a minimum of less than 8 p.p.m. in summer to a maximum of approximately 14 p.p.m. in winter. The percentage of saturation ranges from 90 to 105%; see Report of Engineering Board of Review of the Sanitary District of Chicago (1925), table 10, page 43.

Dissolved oxygen is from time to time in this report referred to as D.O.

[3]This explanation is taken from page 43 of Report of the Engineering Board of Review, cited *supra*.

absence of dissolved oxygen, an odor nuisance may be expected in the presence of a substantial B.O.D.[1]

General Description of Sanitary District Treatment Plants

A general description of the treatment works and methods of the Sanitary District, including those then complete and those then planned, will be found in the 1929 reports of Special Master Hughes on re-reference at pages 8, ff. The following summary of the plants as actually constructed, is taken from the testimony of Mr. H. P. Ramey, Assistant Chief Engineer of the Sanitary District.

The Sanitary District comprises 442 miles of area. It is divided into four projects:

1. **North Side Plant.** This plant is of the activated sludge type, originally designed for an average flow of 175 m.g.d. with a maximum of 263 m.g.d. It went into service on October 3, 1928, but was not in complete operation until June 28, 1930. On May 19, 1937, an average capacity of 250 m.g.d. was obtained by the addition of twelve new settling tanks. The effluent passes to the North Shore channel. The excess activated sludge and the preliminary sludge from the preliminary settling tanks are pumped 17.5 miles to the Southwest works for ultimate disposal.

2. **Calumet Plant.** This is also of the activated sludge type, designed for an average flow of 136 m.g.d. and a maximum of 200 m.g.d. and has been in service since September 3, 1935. The effluent is discharged into the Calumet-Sag channel, east of Blue Island. The excess

[1]The extent of B.O.D. rather than the amount of dissolved oxygen is the final test of extent of pollution. But there may be a B.O.D. in drinking water which contains much dissolved oxygen. Thus the water at the mouth of the Chicago River in June, 1940, had a B.O.D. of 1.3, although it contained 9.9 p.p.m. of dissolved oxygen.

sludge is conditioned, de-watered, dried for burning or sold for fertilizer.

3. **West Side Plant.** This is of the Imhoff tank type, designed for an average flow of 472 m.g.d. with a maximum of 700 m.g.d. From these tanks sludge is pumped to drying beds. After the sludge is dried to a workable condition, it is cleaned off the beds by stripping machines and hauled three miles to a dumping area. The effluent is discharged into the main channel. The result is poorer than that obtained at the North Side and Calumet plants because treatment by the Imhoff tank method does not provide a complete degree of treatment. Present plans call for giving activated sludge final treatment to West Side sewage at the Southwest plant now to be known as the West-Southwest plant.

4. **Southwest Side Plant.** This is now known as the West-Southwest plant, but in this report is usually referred to as the Southwest plant. It is of the activated sludge type, and said to be the largest sewage treatment plant in existence. It was originally designed for an average flow of 400 m.g.d. with a maximum of 600 m.g.d. Final plans contemplate its enlargement to a capacity of 900 m.g.d., of which 600 would be completely treated and 300 partially treated; the West Side sewage would be given secondary treatment. The first battery of activated sludge was put in service on June 27, 1939, and de-watering and incineration of sludge has operated continuously since August 28, 1939. The Racine Avenue pumping station, which handles about half the sewage in the project, was not put into service until March 20, 1940. The effluent is discharged into the main Canal. To this plant comes all industrial waste from the stockyards. The excess activated sludge is mixed with the North Side sludge, concentrated into sludge concentration

tanks, treated, de-watered, dried for burning or sold as fertilizer. The Southwest plant is known as the West-Southwest plant because ultimately it will provide complete treatment for the Southwest Side sewage, and final treatment for the West Side sewage. So far the only sewage treated is the Southwest side sewage (and that only incompletely).

Cost of Sewage Treatment Plants and Progress Made in Their Construction and in Treatment of Sewage

Up to December 31st, 1928, the Sanitary District had expended on sewage treatment works $63,355,422 and the District then estimated that the additional cost of completing the program would be $176,166,000.[1] The grand total cost of the program would, upon these figures, have been $239,521,422. At January 1st, 1941, the District estimated that the total cost would be $178,075,611. This is about $61,000,000 less than the 1928 figures. The difference is due to a number of changes in the plans of the Sanitary District as well as to savings in cost.

Of the total of $178,075,611 there was incomplete at January 14, 1941, work estimated to cost $11,756,900, of which $2,392,000 had been contracted for on that date and $9,364,900 had not yet been contracted for. The work to be done after January 14, 1941 is chiefly at the West-Southwest plant, the largest item being for additional final settling tanks and aeration tanks and completion of the sludge handling plant.

Some changes in the program of the Sanitary District were made as a result of recommendations in 1934 by a Commission appointed by the PWA (Federal

[1]The figures appear in the report of Special Master Hughes, on re-reference at p. 6, ff.

Emergency Administration of Public Works), from whom the Sanitary District obtained a loan and grant. After these recommendations were made the District made studies and tests with respect to treatment of West Side effluent which extended over three years. In May, 1940, following a report from the District a Board of Review of the PWA recommended that the best method of supplementing the treatment now given to the West Side sewage lay in enlarging the Southwest activated sewage plant. Grants made by the PWA to the Sanitary District aggregate $16,692,000 and there is pending an application for an additional grant of $1,900,000.

On July 1st, 1940, the Sanitary District had on hand in cash and debt incurring capacity, monies estimated to be sufficient to pay for 90% of all future work, and if assessed valuations remain the same, the District's debt incurring capacity will increase at the rate of about five million dollars a year. The District's financial resources are now adequate to assure the completion of its program without further interference because of financial difficulties, but this was not true until May, 1940, when for the first time in the past three years the bonds outstanding were substantially less than the debt incurring capacity. The record contains numerous statements by Mr. Pearse, Sanitary Engineer of the District, indicating that the progress of the work has been constantly delayed by lack of funds up to as recently as May, 1940.

At the outset of the hearings, I stated that I understood the *per curiam* opinion of the Court handed down on April 3, 1940 (309 U. S. 569), to be a final adjudication that Illinois had "failed to show that it had provided all possible means at its command for the completion of the sewage treatment system" as required by the Court's decree of April 21, 1930, as specifically en-

larged in 1933, and that "no adequate excuse had been presented for the delay", and that I did not construe the reference to me as authorizing any inquiry into excuses for delays. I did not, therefore, inquire into the reasons for delays in making applications to the PWA or the reasons for the delays in letting contracts or the circumstances justifying the delay of three years in making studies for a definite program following the PWA recommendations in 1934.

The various tables which accompany this report as appendices show the following pertinent facts:

(1) The flow at all the treatment works in millions of gallons daily increased from 67.9 m.g.d. in 1928 to 338.3 m.g.d. in 1931. There was then comparatively little increase until 1936, when the flow became 464.9 m.g.d. In 1937 there was a further increase in flow of about 80 m.g.d. with little change in 1938. In 1939 the flow became 669.9 m.g.d. and in 1940 it reached 929.9 m.g.d.[1] The system today is stated to collect all but 40 m.g.d. of a total sewage flow of over 1,000 m.g.d.

(2) Volatile solids discharged into the Canal amounted in tons in 1938 to 123,100 and in 1939 to 115,658. In 1940 the figure had declined to 76,472 and in 1941 it is estimated that it will be 40,910, or only about one-third of the 1939 total.[2] Volatile solids represent organic matter and most of the putrescible material in the sewage.

(3) The total sludge and grit discharged into the Canal aggregated 53,970 tons in 1939. This was more than in any of the three preceding years; in 1938 it was 44,198. In 1940 it was only 20,224. Since the end of

[1]See Table 2 in appendix. See also Table 3 showing increase in dry solids removed from 54.1 tons in 1929 to 422.7 in 1940.

[2]See Table 4 in appendix.

September, 1940, no sludge and grit has been discharged into the channel.[1]

(4) The efficiency of the various plants in the last three years, as reflected in reduction of B.O.D., is as follows:

	1938	1939	1940
North Side	92.2	93.5	94.6
Calumet	83.1	87.0	90.7
West Side	47.4	53.7	50.0
Southwest			67.3[2]

The weighted average percentage of B.O.D. reduction in all plants for 1940 was 67.8.[3]

The particularly poor result at the West Side plant is due to the fact that the treatment there is only by Imhoff tanks and not by activated sludge. The poor result at the Southwest plant appears to be due at least in part to the inadequacy of the present equipment of the plant.

(5) The report of the Southwest treatment plant by months for 1940 shows a striking decline in efficiency of result, as indicated by the following summary:[4]

Month	Total Flow m.g.d.	Complete Treatment	B.O.D. Reduction
January	287	287	91.3
April	252	122	64
July	287	168	70.8
October	361	248	65.1
December	358	139	47.1
Average	313	192	67.3

[1]See Tables 5 and 6 in appendix.

[2]1940 was the first year of complete operation of the Southwest plant.

[3]See Table 8 in appendix.

[4]See Table 7 in appendix.

In argument it was suggested that one reason for the decline in results was that the Racine Avenue pumping station, which carries stockyards sewage, had been cut in only on March 20, 1940. As the stockyards sewage is strong, this would explain a decline in B.O.D. reduction from January to April, but it would not explain the decline in total flow between those months, nor would it explain the extreme further decline in B.O.D. reduction from 70.8 in July to 47.1 in December. It was also suggested that the strength of the raw sewage B.O.D. had increased within these months. However, the strength of the raw sewage in December was not substantially greater than in November, while the percentage of reduction in December was only 47.1 as compared with 67.2 in November. The strength of the raw sewage in October was substantially the same as in January, but the percentage in reduction in B.O.D. in October was only 65.1 as compared with 91.3 in January. It may also be noted that at the Southwest plant the total number of gallons receiving complete treatment in December was only 139 as compared with 222, 248 and 236 in the three preceding months.[1]

Mr. Pearse said in answer to my inquiry as to the poor recent showing at the Southwest plant, "we are hoping for better and more consistent operation during 1941" and "I think that it will necessitate a closer watch on the operators in the plant than we have had heretofore by those of us in the main office. That is the best explanation I can give you."

Mr. Pearse explained the deficiencies of operation at the Southwest plant chiefly on the ground that there was not sufficient blower capacity to carry continuously a flow of 400,000,000 gallons per day. He said,

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[1]See Table 7 in appendix.

> "I am afraid that we are under-blowered because our money did not go far enough to buy sufficient blowers with a nominal capacity of 400,000,000 gallons, and as a matter of fact, I believe the PWA, if I am not mistaken, cut out one blower that we urged them to buy at the time."

There is also a shortage of compressors, which were "advertised for within the last few months probably." Mr. Pearse could not answer offhand why contracts were not let sooner, "I think one answer was that we were waiting until the end of the winter, early spring, to find out how much money would be available and to what extent they should go ahead." Following the action of the Board of Review of the PWA, steps were taken to get out the specifications and advertise for the blowers. There is also a need for additional vacuum filters and eight now are under contract, bringing the total up to 32. "We are trying to put in vacuum filters in connection with the other equipment as fast as we can get the money. We have got eight on order and we will be buying more."

The deficiency in equipment is particularly at the end of the treatment process in that portion thereof which consists of de-watering, heating and drying the residue of the sludge and making it marketable for fertilizer. The shortage of equipment at this point makes it impossible to run all the sludge through the plant. A substantial part of the sewage flow was discharged as sludge into the channel without complete treatment, i.e., only after a short period of preliminary settlement. Thus, in the first six months of 1940 there continued to be a substantial amount of sludge discharged into the channel from the Southwest treatment plant.

In August, 1940, shortly after the hearings before

me had begun, arrangements were made to send to the West Side plant the sludge which was then being discharged into the channel from the Southwest plant. This sludge is now being run through the Imhoff tanks at the West Side plant and then placed into lagoons. In the last few months of 1940 lagoons were constructed on the site of the West and Southwest works covering an area of 37 acres. The cost was about $38,000 as a WPA project, of which the Sanitary District contributed about 38%. There is available at this location a further area of about 20 acres on which additional lagoons might be constructed. Based upon the present short period of preliminary settling (13 minutes) given at the Southwest works to the flow which is then sent over to the West Side plant, the lagoon capacity available should suffice into 1943. If a longer period of settling be employed, the capacity would be exhausted in the winter of 1941-42. Further land for lagoons is available at a point four miles removed. These lagoons are situated in an industrial area and their use will create no nuisance complaints.

As a result of this lagooning (but only since the hearings before me began) the discharge of sludge into the Waterway by the Sanitary District has entirely ceased. Other putrefiable material, however, continues to be discharged into the Waterway, chiefly in suspended solids contained in the incompletely treated effluents of the West Side and Southwest plants.

Probable Conditions at Lockport and Joliet in the Summers of 1941 and 1942

In prognosticating the situation at Lockport in 1941 and 1942, the experts on both sides agreed that there were to be taken into account, on the one hand, the

sources of B.O.D. and, on the other hand, the sources of dissolved oxygen.

The liability side (sources of B.O.D.) is made up in part of the demand asserted by the old sludge deposits in the Canal and in the Pool. All the experts agreed that it is impossible to evaluate precisely the demand exerted by these deposits in pounds of B.O.D. One can only guess at this. As previously noted, all of the experts agreed that the B.O.D. of sludge decreases about one-half after four months of summer, that at the end of the second summer, it will be only about one-fourth the initial demand and at the end of three summers, possibly only 3 to 5% thereof. Therefore, the B.O.D. exercised at Lockport in 1941 by old sludge deposits will be materially less than in 1939 because the sludge deposits of the two years preceding 1939 materially exceeded in volume the deposits for the two years preceding 1941.[1] In 1942 the situation as to the influence of old sludge will be further improved by the considerable further reduction of deposits in the channel in 1941.

According to the estimates of the Sanitary District, the chief source of B.O.D. at Lockport in 1941 and 1942 will be the B.O.D. from the West Side and Southwest effluents.[2]

The Sanitary District concedes that the B.O.D. demands at Lockport in the summers of 1941 and 1942 will be far less than they were in 1939, which is the summer in which the complaints at Joliet were the most pro-

[1]See record of volatile solids deposited in channel in appendix, Table 4.

[2]This will be due to (a) incomplete treatments afforded by Imhoff tanks at West side and (b) inadequacy of equipment at Southwest plant to permit complete treatment of the plant's capacity flow and the consequent necessity of discharging into the Canal effluent incompletely treated.

nounced, and also far less than in 1940.[1] A comparison of the years upon the revised figures submitted by the Sanitary District is as follows:[2]

Sources of B.O.D. lbs. per day—	1938	1939	1940	1941	1942
B.O.D. demands from old sludge deposits	519,000	475,000	237,000	118,500	60,000
B.O.D. demands from current deposits of sludge and/or effluents	763,800	749,000	529,000	406,000	406,000
Total	1,282,800	1,224,000	766,000	524,500	466,000
Conditions at Lockport—					
Flow—c.f.s.	6,752	3,336	3,469	3,200	3,200
5-day B.O.D.					
—p.p.m.	17.3	30.2	20.6	21.0	17.6
—lbs. per day	630,800	562,300	386,000	364,500	303,000
Dissolved Oxygen—					
—p.p.m.	0.2	0.0	0.0	0.0	0.0
—lbs. per day	6,070	0	0	0	0

After submitting his revised figures Mr. Pearse testified that he would be disposed to again revise them so as to reduce to 346,000 the figure of 406,000 appearing in the 1941 and 1942 columns (as B.O.D. demands from current deposits of sludge and/or effluents) in order to give proper weight to probable decreases in B.O.D. from West Side and Southwest effluents.

The accuracy of the Sanitary District figures is challenged by Mr. Howson, who contends that the conditions

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[1]Illinois originally put in evidence estimates which showed much greater anticipated improvement in the B.O.D. at Lockport in 1941 and 1942. At the time of oral argument it was stated that these estimates had been made up in error and the estimates shown in the text were substituted.

[2]The District's revised figures appear in full in the appendix, Table 9.

at Lockport in the summers of 1941 and 1942 will be materially better than estimated by the Sanitary District.[1]

It would take too much space to attempt to set out a full analysis of the conflicting views. Mr. Howson's figures are apparently based upon his view that by proper diligence in completing work at the Southwest plant, no effluent from it would contribute B.O.D. in 1941 and 1942 and that the West Side effluent would also be completely treated in 1942. In the actual present status of the Sanitary District program, it seems clear that this expectation cannot be realized as to 1941 and doubtful if it will be accomplished by 1942. Mr. Howson also contends that the Sanitary District has overestimated the B.O.D. effect of old sludge deposits and has failed to give sufficient weight to the re-aeration which will be acquired through the flow to Lockport, particularly in view of the scouring of the channel as a result of the 10-day experimental flow. Here again are presented issues upon which a layman must have difficulty in resolving a conflict between experts.[2] It is probable that

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[1]Mr. Howson originally calculated that in the three summer months of 1941 and 1942 the B.O.D. at Lockport would be 7.3 p.p.m. and 4.8 p.p.m.

On the figures originally submitted by the Sanitary District, the B.O.D. at Lockport in 1941 was not extended, but on the other figures shown, Mr. Howson calculated that the B.O.D. in Lockport would have been 10.3 p.p.m. as compared with the figure of 21.0 p.p.m. which appears in the revised District figures.

Even upon the revised figures of the District, Mr. Howson contends that the B.O.D. at Lockport in the summer months of 1941 and 1942 should be determined by taking that proportion of the estimated sources of B.O.D. in those years which (a) the actual B.O.D. at Lockport in the earlier years was to (b) the total sources of B.O.D. in earlier years. On this basis, even upon the revised figures of the District Mr. Howson claims that the B.O.D. at Lockport in the summer months of 1941 and 1942 will be 13.5 p.p.m. and 11.5 p.p.m. instead of the District's revised estimates of 21.0 and 17.6.

[2]I considered from time to time whether I should call experts of my own selection, but concluded not to do so, in part, for the reasons assigned for a similar conclusion by Special Master Hughes in his report upon re-reference (1929), p. 127, and in part, because such employment would have occasioned additional delay in an inquiry which I have already found it difficult to make "summary", as directed in the order of reference.

Mr. Howson's figures are too optimistic, while those of the Sanitary District go too far in the other direction. However, it seems sufficient to note that even upon the Sanitary District's figures, the total sources of B.O.D. demands in 1941 in pounds will be less than half of the 1939 figure, and the 5-day B.O.D. (which Dr. Mohlman agrees to be the final test of pollution) will in 1941, in parts per million, be only two-thirds of the 1939 figure. In 1942 there will be further substantial reductions according to the District estimates. The figures, therefore, seem to make it clear that the pollution at Lockport (and correspondingly at the Pool) will be materially less in 1941 and 1942 than in 1939. This result would indeed seem to be the necessary consequence of the great reduction in tons of volatile solids discharged into the Canal in 1940, and to be discharged in 1941 and 1942, as compared with amounts discharged in 1939 and earlier years.[1] This is further confirmed by the testimony given before me by the experts for Illinois, who at the outset of the hearings, agreed that conditions in 1941 at Joliet and Lockport would be better than in 1940, and *a fortiori* substantially better than in 1939. They also agreed that an additional improvement was to be expected in 1942, when further progress will have been made in sewage treatment and the effect of past sludge deposits will have been further reduced.

It is true that there will be, according to the Sanitary District estimates, no dissolved oxygen at Lockport in the summer of 1941 or 1942. There was also none in the summer of 1939 and even in the summer of 1938 there

[1]See appendix, Table 4.

was only 0.2.[1] This 1938 figure would fall below the minimum of 1 p.p.m. of D. O. which the Sanitary District in its modified petition claims to be essential. Yet in 1938 the authorized diversion from the Lake was 5,000 c.f.s., the actual flow at Lockport was 6,702 c.f.s. (including domestic pumpage), and there were no special complaints in Lockport or Joliet (although annoyance and discomfort from the odors have always been experienced and expressed).

The following are the average D.O. and B.O.D. figures at Lockport for January of the last four years:[2]

	1938	1939	1940	1941
Dissolved Oxygen	7.4	0.5	1.8	0.6
B.O.D.	22.6	28.5	14.8	22.9

The dissolved oxygen for the month of January in 1941, was substantially the same as in 1939, but materially less than in 1940,[3] and greatly less than in 1938, when the diversion was larger. The B.O.D. for January was, however, substantially less in 1941 than in 1939, and about the same as in 1938 (when the diversion was

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[1]Dr. Mohlman testified, "I do not think conditions prior to 1939 are by any means satisfactory conditions. We had zero dissolved oxygen at Lockport. We are merely keeping up with what we have had for many years, and we are not improving conditions down there after the expenditure of all this money for our treatment plants."

[2]The Sanitary District has records of the L.O.D. and dissolved oxygen at Lockport extending back as far as 1925. These records show in 1939 a higher B.O.D. and a more extended period of no dissolved oxygen than in any other year. However, in every other year there was a period in the summer in which the dissolved oxygen went down nearly to zero for a few months; in many of the years the dissolved oxygen in the summer was actually zero for a part of the time.

[3]The lower dissolved oxygen figures in January, 1941, as compared with January, 1940, may be partly explainable by the slightly lower flow at Lockport in 1941 (2,781 c.f.s. as compared with 2,949 c.f.s. in 1940). The District states that the low average in 1941 is due to the effort to conserve diversion this winter in preparation for the demands next summer.

6,752 c.f.s.)[1]

Insofar as one can reason from January to June, the B.O.D. figures seem to support the view that conditions in June, 1941, will be a great deal better than in 1939. The dissolved oxygen figures indicate that June, 1941, will be no better as to odor conditions than 1939; but, as has been noted, the District representative testified that the B.O.D. figures are the controlling evidence of degree of pollution.

As a subsequent statement shows, the 10-day flushing in December appears to have cleaned much sludge out of the channel as a whole, while at the same time leaving more in the Pool than there was before flushing.[2] To the extent that more putrescible material has been deposited in the Pool, conditions in 1941 will be adversely affected. A counterbalancing influence will be the cleaning out of the channel above the Pool, which should reduce the B.O.D. in the water on the way to the Pool and enable it to contribute more dissolved oxygen. In the opinion of Dr. Mohlman the hopes entertained in this regard are denied by the fact that the dissolved oxygen at Lockport in January, 1941, was less than in January, 1940, and not much more than in January, 1939.

I conclude that while it is reasonably certain that the B.O.D. conditions in the summers of 1941 and 1942 will be better than those in 1939, it is also most probable that there will be no dissolved oxygen at the Pool in the summer of 1941 and that there are likely again to be offensive odors at Joliet and Lockport. Weather conditions will undoubtedly have a large influence not only upon the existence of odors but also upon the susceptibility of individuals to them.

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[1]For the full years 1938, 1939 and 1940, the average B.O.D. and D.O. figures at Lockport were as follows:

	1938	1939	1940
Dissolved Oxygen	2.5	0.4	0.8
B.O.D.	18.4	26.0	20.1

[2]See *infra*, pp. 78-82.

V.

AVAILABLE REMEDIAL OR AMELIORATING MEASURES

The opposing States pointed out that the first step in the improvement of conditions in the Waterway would be to discontinue the discharge into it of sludge. As shown by the statement *supra*, page 55, this was actually accomplished as of the end of September, 1940, after the hearings before me had begun, but a considerable quantity of putrescible material continues to be deposited into the Canal in the form of partly treated effluents.

Other possible remedial measures which were suggested in the hearings before me are now taken up in order.

Dredging, Draining or Flushing Brandon Road Pool

As the complaints which led to the present hearing emanate chiefly from those residing along the banks of the Waterway at Joliet, within one to two miles of the Brandon Road Pool, it seems quite clear that they are attributable chiefly to the conditions at the Pool. I therefore gave particular attention to various suggestions as to what might be done to ameliorate conditions there.

As noted at page 9, the wide section of the Brandon Road Pool, which reaches a maximum of 1,400 feet, extends for about half a mile at the southern end of Joliet, between one and two miles from the residences of most of the complaining witnesses. The depth of the Pool varies from 10 to 20 feet below the water surface to the sludge deposits; in the center this depth was estimated by Dr. Mohlman of the Sanitary District at 18½

feet and by Mr. Andrew of the United States District Engineer's office at 19 to 22 feet. The elevation of the Pool is 539 feet above sea level. It contains a water volume of about 120 million cubic feet. The original volume was about 151 million cubic feet.

The United States Engineers made soundings in 1934, 1936 and 1939. Between the 1934 and 1936 soundings and those made in 1939, Mr. Andrew estimated that there had accumulated in the Pool from 1,250,000 to 1,500,000 cubic yards of deposited material. Of this about 107,000 cubic yards represented materials deposited by the United States from dredging, and the balance represented accumulated sludge deposits. The deposited material extends at some points for 2 feet and at other points from 6 to 10 feet. At other points in the Sanitary Canal, there are deposits ranging from 2 to 4 feet, but nothing comparable to those in the Pool.[1]

Mr. Andrew testified that in his opinion an increase in the flow to 5,000 c.f.s. would not remove this accumulated deposit, nor would it flow out by opening the gates of the locks. It would have to be taken out by hydraulic dredging, the moisture content ranging from 60 to 99%. Most of this material is in the lower quarter of the Pool. The dredging would cost about 40 cents per cubic yard or between $500,000 and $750,000; it would take from 6 to 9 months. The material removed would have to be deposited on adjacent land. Several hundred acres would be required, but there is vacant land available for this purpose.

[1]The sludge deposits accumulated even while the authorized diversion from Lake Michigan was 6,500 c.f.s. and 5,000 c.f.s.

Mr. Howson, the expert for the opposing States,[1] thought that the dredging of the material referred to by Mr. Andrew might not cost more than $400,000. The material would probably have to be lagooned on spoil banks. A nuisance condition might be caused at the point of lagooning. This might be controlled to some extent by the use of chlorination at a further expense, no figures as to which were furnished me.

The experts on both sides agreed that the denser material deposited in the Pool represents accumulations of previous years which have largely lost any potency to cause nuisance. Studies which have been made indicate that after four months of summer, the B.O.D. of sludge decreases about one half; that at the end of a second summer, the B.O.D. will be only about one fourth of the initial rate; and after three years, the rate is reduced to possibly 3 to 5% of the initial rate. It appears that the hydraulic dredging of the deposited material in the Pool would remove for the most part material no longer the cause of offense.

While Mr. Howson said that "some good" might be accomplished by dredging this material, he had his "doubts about its practicability as compared to more

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[1]Mr. Howson was the leading sanitary expert witness for the opposing States. He is a graduate of the University of Wisconsin, and since 1913 has been a member of the firm of Alvord, Burdick & Howson, who specialize in hydraulic and sanitary engineering, including sewage and sewage disposal.

Leading witnesses on technical questions for Illinois were Mr. Langdon Pearse, Sanitary Engineer of the Sanitary District, Dr. F. W. Mohlman, its Director of Laboratories, and Mr. Horace P. Ramey, its Assistant Chief Engineer. Mr. Pearse is a graduate of Harvard College and of the Massachusetts Institute of Technology, and has been connected with the Sanitary District since 1909. Dr. Mohlman is a graduate of the University of Illinois and came to the Sanitary District in 1919 as Chief Chemist. Mr. Ramey is a graduate in civil engineering of the University of Michigan and has been connected with the District since 1907.

All these gentlemen testified also in the hearings before Special Master Hughes on re-reference.

effective and positive methods such as chlorination and methods of that type."

Dr. Mohlman thought that the dredging of the Pool would dislodge sludge deposits and disseminate the sludge, bringing it to the surface of the water and thereby intensifying odors. Dredging might remove some of the large bulky deposits, "but whether it would remove the actual putrefactive material, I think, is questionable, and it doesn't seem to me a practical method of getting rid of the odors and the putrefaction in those channels there and the pool." If the sludge is deposited on spoil banks, "there would be odors wherever it was deposited, even if it was covered with water, and the escaping gases would cause a nuisance."

Mr. Pearse deemed it impractical to accomplish much by dredging and removing material which had been decomposing for two or three years. He thought it an "intensely speculative question. * * * "I would think a good many times before I would want to spend the public's money on such a venture."

In view of the foregoing and particularly of the agreement of the experts on both sides that most of the material that would be taken out by dredging is the old material which has largely lost its potency as a cause of nuisance, I do not think that hydraulic dredging of the Pool could be counted upon to eliminate the odors complained of at Joliet. Dredging would also raise a new set of problems as to odors from material deposited on spoil banks.

After hearing Mr. Andrew's original statement, I abandoned for the time being any further inquiry as to

the possibility of draining the Pool by opening the locks since it appeared from his testimony that the material to which he referred would not flow out if the locks were opened. It developed, however, from subsequent testimony of the sanitary engineers that the material in the Pool which they considered responsible for the odors complained of was light flocculent material containing from 90 to 98 or 99% moisture, which they believed would flow out of its own weight if the locks at Brandon Road were opened and the Pool drained. Mr. Howson was strongly of the view that the draining or flushing of the Pool would be beneficial in removing active sludge represented by the flocculent material. He thought that the objectionable material would cause no trouble down the river as it could be deposited in the Dresden Island Pool, which is several times larger than Brandon Pool and in a very sparsely settled area, and that the balance would go downstream. The other experts shared the view that this flocculent material would flow out upon a flushing or draining.

I thereupon renewed my inquiry as to the feasibility of draining the Pool. The United States Engineers were of the opinion that this was not feasible for a variety of reasons. They were of the opinion that the operation would have to be repeated two or three times as the flocculent material would not come through at one time. The gates could not be opened completely without causing risk of damage to navigation. The opening of the gates at Brandon Road would necessitate operations at the locks and dams at Dresden Island and Marseilles. If the gates were only partly opened and the Pool drained only in part from time to time, operations would be necessary at the locks at Dresden Island and Marseilles. They feared that the flocculent material carried down to other points

might cause nuisance conditions at those points.[1] It was also suggested that the Government would then be required to do more dredging down the river to maintain navigation channels at increased expense and possible incidental interference with navigation, particularly at the pools at Dresden Island and Marseilles. To empty the Brandon Road Pool or even to reduce its level would interfere with water intakes of several industries. The opinion was expressed by the Government engineers that to completely drain the Pool at one time by cutting off the flow from the Sanitary District might result in reversals of flow in the river and pollution of the lake water at the mouth of the Calumet River. Even a reduction in the diversion to a total flow of 1,700 c.f.s. (including domestic pumpage), it was suggested, might make difficulty in the event of a rainfall or if seiches occurred in Lake Michigan materially lowering the lake levels during that period. Draining the Pool would not remove the sludge deposits other than the flocculent material and such other material could be removed only by hydraulic dredging. The Government engineers stressed their view that the removal of the flocculent material, if it could be accomplished, would not give complete relief as long as additional material continued to be deposited in the channel from the treatment plants of the Sanitary District.

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[1] It appears that the region immediately below Joliet is relatively sparsely settled. The nearest large town is Ottawa with a population of about 16,000, at a distance of about 50 miles south of Joliet. Other towns on the Waterway below Joliet, and their approximate populations and distances from Joliet, are:

	Approximate Population	Approximate Distance from Joliet in Miles
Peru	9,000	60
LaSalle	13,000	65
Peoria	105,000	130
Beardstown	6,500	200

Additional water from the convergence of the Kankakee and Fox Rivers between Joliet and Peru affords additional dilution in the Waterway.

For all of these reasons the Chief of Engineers stated definitely his unwillingness to agree to the drainage of the Pool at this time.

Notwithstanding the views thus expressed by the Chief of Engineers, reference continued to be made during the course of the hearings to the possibility of relieving nuisance conditions by removing from the Brandon Road Pool some of the flocculent material of recent origin which was arrested there as in a catch basin. The suggestion finally developed that a 10-day flow of 10,000 c.f.s. would be of material benefit in washing out this material without necessitating any opening of the locks. All of the experts agreed that such a flushing of the Waterway would be helpful and desirable. At my suggestion counsel for the opposing States stipulated that the Court might enter such an order upon the understanding that their position in the case would not be in any manner prejudiced by the agreement. I ascertained from the Chief of Engineers that the War Department would offer no objection from the standpoint of interference with navigation. Accordingly on November 25, 1940, the Court entered an order permitting a flow of 10,000 c.f.s., in addition to domestic pumpage, for 10 days beginning on December 2, 1940.

Results of Experimental 10-Day Flushing

During the test the total flow at Lockport averaged 9,973 c.f.s. and the diversion flow at Lockport, less water pumpage in the Chicago area, was 8,430 c.f.s. This was less than the amount permitted by the stipulation and the order of the Court, but was the maximum flow capacity of the drainage Canal at the time of the test. The weather in the experimental period was very cold, which decreased the flow from tributaries, and, accordingly, the expected stages in the lower reaches of the Waterway were not

reached and damages to low lying lands, which had been feared, were not suffered.

The level of the Pool at the Brandon Road Dam was lowered half a foot to induce the flow. The experts had thought that a lowering of the level by about 5 feet would make the experiment more effective. The War Department was unwilling to permit a lowering to this extent because of suggested difficulties with the intake pipes of various industries. A further lowering of the level by one foot was, however, permitted for 36 hours over the weekend of December 7th and 8th.

The flushing appears to have scoured out the Waterway above the Brandon Road Pool pretty well. However, much of the material deposited in the upper reaches of the Waterway, which was swept down the stream by the increased flow, did not carry through the Pool. The figures are shown as follows in the report upon the test prepared by Dr. Mohlman:

Total tons suspended solids carried into Pool	84,010
Total tons suspended solids carried out of Pool	21,123
Balance deposited in Pool	62,887
Percent deposited	74.8%
Percent transmitted	25.2%

The above totals include both volatile and non-volatile suspended solids. Figures as to the volatile suspended solids are as follows:

Deposited in Brandon Pool	27,067 tons
Transported out of Pool	7,512 "
Percent transported	27.8%

The volatile material is that which is the chief source of nuisance as it represents chiefly organic matter.[1]

[1]Volatile solids are determined by heating dried solids to a temperature of 650° C.; the loss of material is the volatile or organic matter.

Thus, of the offensive material carried into the Pool by the flushing, a larger percentage was taken out than of the total material taken into the Pool. This was confirmed by the fact that 52.8% of the tons of B.O.D. carried into the Pool were carried out of it.

The average velocity in the middle of the Pool during the experimental flow ranged only from .47 to .55 feet per second. The maximum velocities ranged from 1.33 to 1.58 and the minimum velocities near the banks ranged from 0 to 0.07. Mr. Ramey estimated that velocities in the Pool are generally about one-third or one-fourth of the velocities in the main channel.

Dr. Mohlman estimated that the additional deposits of material carried into the Pool by the 10-day flushing amounted to as much as 2 to 2½ feet and perhaps aggregated 524,000 cubic yards. Mr. Andrew said that soundings indicated increased deposits of as much as 9 feet at certain points, but that there is still a minimum depth of 13 feet in the channel, which is in excess of the minimum required of 9 feet and more than that at other points in the Waterway, and the government does not anticipate more dredging at this time.

Opinions were in conflict as to whether a lowering of the level of the Pool by 5 feet while the flushing was in progress would have resulted in sweeping out more flocculent material. Mr. Howson thought it would have done so, but this view was not shared by Messrs. Andrew and Ramey, who felt that, in view of the low velocity in the middle of the stream, a lowering of 5 feet would have been of no appreciable benefit. Mr. Howson frankly said that there could be no certainty on this point without a series of prolonged experiments and more data than was available.

I inquired of all the experts as to why their expecta-

tions as to the effect of the flushing in removing the flocculent material from the Pool had not been realized. Mr. Andrew felt that he had been mistaken in his estimate as to the character and extent of the flocculent material and had thought that there was more light material that would be carried through readily at extremely low velocities. Mr. Ramey thought it was because there had been "such a tremendous quantity of material scoured out of the main channel above the Brandon Road Pool and not scoured out as quickly as hoped", which had retarded the movement through the Pool. Dr. Mohlman had hoped that there would be more localized velocity. Mr. Howson thought that the trouble was due to the fact that the material was 4 or 5 times as dense as he had expected.

The result seems to indicate the degree of uncertainty which must attend all expert opinion, even where it is in accord.

Opinions differed as to the results accomplished by the flushing experiment. All witnesses agreed that taking the stream as a whole from the point where the sewage enters the channel through the Brandon Road Pool, a considerable benefit had been accomplished since a very considerable amount of deposited material was taken out of the Waterway between these points. All witnesses also agreed that the effect of the extensive scouring out of the channel above the Brandon Road Pool should have a beneficial effect on the conditions in the Pool since the water in the upper stretches of the Waterway would come to the Pool removed from the effect of the sludge deposits which had been swept out, and therefore richer in oxygen content. Mr. Howson felt that this would offset the disadvantage of the deposit in the Pool of the material which had been brought down

from the upper stretches. Mr. Ramey and Dr. Mohlman conceded a beneficial effect from the relative purification of the water above the Pool, but Dr. Mohlman was doubtful whether this would offset the effect of the additional material deposited in the Pool. The difficulty of prognostication is indicated by the fact that the dissolved oxygen at Lockport in January, 1941, is less than it was in 1940, notwithstanding the fact that the flushing experiment scoured out of the channel at Lockport so much of the material that had been accumulated at and above that point. During the experimental flow and for about a week thereafter dissolved oxygen at Lockport was considerably in excess of the year before, but thereafter the dissolved oxygen declined.

If the flushing experiment should in fact prove to have made the conditions in the Pool any more unfavorable in 1941 than they would otherwise have been, the rights of Illinois should not be enlarged or those of the opposing States diminished by that fact, as it was understood that the experiment was for the benefit of Illinois and should not prejudice the opposing States in any way, and counsel for those States agreed to the flushing upon that understanding. Illinois had all the chance of gain by the additional diversion, to which the opposing States consented for the ten day period of the test, and it took whatever risks were involved. The additional water which during the test came through the wheels of the Sanitary District powerhouse at Lockport generated power worth $12,500, of which the District had the benefit.

Chlorination of Waterway

The opposing States urged the use of chlorine to eliminate the odors complained of at Lockport and Joliet. On this point their leading witness was Mr. Linn H.

Enslow, a sanitary engineer and chemist, editor of a trade magazine known as "Waterworks and Sewage", and consultant and adviser of the Chlorine Institute, which is composed of chlorine manufacturers. He is a graduate of the Virginia Polytechnic Institute and attended Johns Hopkins University for two years; he is a member of various professional societies and has participated in numerous studies of the use of chlorine.

Mr. Enslow said that the sludge condition at Brandon Pool presented "a bad situation". By that he said he meant that it might require from three to four times as much chlorine to do the same work than if the sludge were not there. He favored the use of chlorine at the Southwest plant and also at Lockport. He thought 3 p.p.m. would be sufficient at the former point, but 6 p.p.m. would be required at Lockport, although 3 might be enough. These estimates were based on the assumption that no new deposits of sludge came into the Pool. If sludge continued to go into the Pool, it might take 12 p.p.m. or even more—"It would be anybody's guess * * * *." "In that situation all you would have would be a giant septic tank served from Chicago. I would not know whether it would take 15 parts or 25".

If the discharge of sludge to the Canal were discontinued by January 1, 1941, Mr. Enslow (testifying in September, 1940) still thought it would take 3 p.p.m. of chlorine at Lockport in addition to 3 p.p.m. at the Southwest plant or a total of 6 p.p.m., to relieve the odor conditions at Joliet and it might take more. At one point he said, "It is a speculation; it is a speculation in anybody's sense."

Mr. Enslow estimated the cost of chlorination at a minimum of $700 and a maximum of $3,000 per day, based upon a unit price of $43.20 a ton; 3 p.p.m.

would be equal to 25 tons. This would have to be continued through the summer months. In addition to costs of chlorine, there would be a cost for equipment. For this Mr. Enslow made a "rough estimate" of $85,000, and thought it would probably cost $115,000 at Chicago to complete the construction of the necessary plant and auxiliaries. He recommended one plant at the Southwest treatment plant and another larger one at Lockport.

Dr. A. M. Buswell, Chief of the Illinois State Waterway Survey, thought that the sludge in the Brandon Pool had received undue emphasis from a technical standpoint in view of its age. He believed an application of 2 to 3 p.p.m. of chlorine below the dam at Lockport costing from $700 to $1,000 a day over a period of not over 100 days would be sufficient to remove odorous substances. In the wider portions of the Brandon Pool, which was a more or less stagnant basin, he thought a chlora-boat (which would "probably" not cost over $10,000) might be used to apply 1 p.p.m. per day in that Pool, which would be adequate there. Thus, it was his "checked opinion" that an average of 3 p.p.m. per day should take care of the situation if sludge were no longer discharged into the Canal, but if sludge continued to be discharged, he thought an average of 5 p.p.m. would be required. Later he estimated that the expenditure of between $1,000 and $1,200 per day for chlorine for a summer's operation would "very largely alleviate the conditions." He said that these were estimates only, not based on accurate survey as he had not expected to testify with respect to the use of chlorine, but it remained his opinion that the use of chlorine to the extent indicated would be as effective as increased diversion in relieving the odor conditions.

Mr. Joseph W. Ellms, Commissioner of the Division

of Sewage Disposal in Cleveland, testified with respect to the use of chlorine at Cleveland. Mr. Ellms was educated at the Massachusetts Institute of Technology and has been consultant at various plants. Cleveland has three sewage treatment plants and a total sewage flow of about 125 m.g.d., or about one-eighth of that of Chicago. Cleveland discharges its sewage effluents into the same water from which it draws its water supply (Lake Erie, directly or through the Cuyahoga River) and has used chlorine since about 1922 "as a sanitary protection to a certain extent to the water supply", but also "to keep the marginal waters in as clean a condition as possible during the bathing season and to prevent any odors which may arise from sewage entering the plants." The application has been at the plants, not to the Cuyahoga River or to the sewers entering the river. 5 to 6 tons a day of chlorine are used in all for about 100 days during the summer months, and the chlorine contracts generally run from about 1,000,000 to 1,200,000 pounds per season. Mr. Ellms said that the cost of a 150-ton plant would be "considerably less than $300,000" and would take 6 to 7 months to build. He agreed that it would be better to apply chlorine before septic conditions had developed and it would be helpful to apply it in several places rather than one since the efficacy of chlorine wears off. Mr. Ellms was familiar generally with the Sanitary Canal and the Brandon Pool and thought that chlorine "could reduce, perhaps eliminate", the odors from hydrogen sulphide that may be produced as a result of decomposition of organic matter in the Brandon Road Pool, "but the continuous feeding in that Pool of partially decomposed organic matter is going to provide a continuing source of hydrogen sulphide, which is, perhaps, the chief cause for complaints at, in and around that Pool."

Mr. Warrick, the State Sanitary Engineer of Wisconsin, testified that he believed chlorination "would have a decided beneficial effect" upon the Waterway. He said it was not possible to determine how long the effect of chlorine would last as this would depend upon sludge, temperature and other conditions. "As a very rough statement" he though the effect of chlorine applied at the Southwest plant might last as much as half an hour, but it might last two hours or "considerably longer". This also would be true of its application at other points. From the standpoint of Brandon Pool, the most beneficial effect would be chlorination at or above the Pool, but it would also be advantageous to put in chlorine at several places above the Pool.

Mr. Howson, the chief expert witness for the opposing States, testified generally to the opinion that chlorination "is a very effective and positive method of controlling odors", and that he believed it would be practical and effective to relieve the conditions complained of at Joliet and Lockport. However, his testimony on the subject of chlorination was based chiefly on that of Mr. Enslow. He calculated that 6 p.p.m. of chlorine would remove a total of 200,000 lbs. of B.O.D. at Lockport. The cost of installing chlorinating equipment at two points (as recommended by Mr. Enslow), one of 25 ton capacity near the Southwest plant and the other of 50 ton capacity near the Lockport powerhouse, would aggregate $360,000. Construction would require from 6 to 9 months. The cost of operation would range from $70,000 to $300,000 for the summer months. He said this was a range of figures given by Mr. Enslow, the application of which would depend upon the quantity of chlorine used. The $300,000 was figured on the continuous application of 9 p.p.m. of chlorine over a 100-day period. 12 p.p.m. would cost one-third more, or $400,000. It seems clear that these estimates are very rough.

The witnesses for Illinois testified that the most important use of chlorine was to protect drinking water by destruction of bacteria. They said that they had never given any consideration to its use for that purpose and were not concerned with it because no community along the Waterway used any water from it for drinking.

The Illinois experts conceded that chlorine is in many situations effectively used to prevent odors. The Sanitary District uses it to a limited extent in two of its small plants for odor control and also uses a small quantity at the Southwest plant, where, however, there is little or no trouble with odors. But, in view of the large accumulations of sludge from past deposits of partially treated sewage and the continued deposit of only partially treated sewage, they were of the opinion that chlorine could not be effectively used in the Waterway to eliminate the odor conditions complained of by the residents of Joliet, even if large quantities were used at great expense.

Dr. Mohlman testified that he had made studies of the use of chlorine fourteen or fifteen years ago and had made chlorine demand tests in the Canal in July, 1940. Laboratory tests could not be depended upon for results in practice. In view of the accumulated sludge deposits and the B.O.D. of the water in the channel and in the Pool, he did not think enough chlorine could be used to prevent putrefaction in the Pool on any basis which would make it a "satisfactory and dependable proposition". The chlorine would be quite quickly absorbed by the B.O.D. demands of the water and if it were to be used with any hope of success, it would have to be administered at least at three points; Damen Avenue, Summit and Lockport, and large enough doses would have to be applied at each point to preserve the effect until another dose was administered later on. On this basis Dr. Mohl-

man estimated that you might require as much as 150 tons of chlorine a day at a cost of between $40 and $50 a ton, or between $6,000 and $7,000 a day during the summer months. If chlorine were used only at Lockport you would need somewhere between 75 and 125 tons. Even at this expense, he did not think that the use of chlorine would be practically effective to accomplish any substantial amelioration of the conditions complained of at Joliet.

Mr. Pearse supported the views of Dr. Mohlman. Chlorine, he testified, does not get rid of the organic matter which causes the nuisance complained of at Joliet. It merely delays decomposition to a point where the chlorine is exhausted in its sterilizing effect and then you have the same nuisance over again. "You could, of course, soak chlorine in and keep down decomposition for miles, but the cost from our situation we regard as impractical."

Mr. C. K. Calvert also testified for Illinois with respect to the use of chlorine. Mr. Calvert holds a degree of Bachelor of Science from Earlham College and since 1936 has been Superintendent of Purification of the Indianapolis Water Company. He was formerly superintendent of the sewage disposal plant at Indianapolis, which has a population of 385,000. Indianapolis has an activated sludge plant with a capacity of about 55 m.g.d., which was brought into service in 1925 but operated for only a partial degree of treatment until 1936. Mr. Calvert testified with particular reference to the disappointing experiences in Indianapolis in 1930 when chlorine was used in the White River in the hope of improving sewage treatment conditions, as the plant was too small and they had no money to build a larger plant. The river is a small one and was badly polluted. An average of 10 p.p.m. of chlorine

was applied and an aggregate of 150,000 pounds was used. The chlorine went into the river with the sewage which had in part been treated with the activated sludge treatment and in part was settled. Laboratory tests had indicated that a reduction of 35% in B.O.D. could be expected, but this did not work out in practice and the reduction obtained in plant effluent was only about 10%. This was at the rate of about 2 p.p.m. of B.O.D. per p.p.m. of chlorine added. Usually the chlorine was gone as soon as the sewage was mixed with the river water. Indianapolis sewage is much stronger than that of Chicago and the B.O.D. at the point at which the chlorine was applied at Indianapolis was about 8 times as great as that of the B.O.D. of Brandon Pool. Residual chlorine was found only on one occasion further away than about 2,000 feet. Mr. Calvert thought Dr. Mohlman's estimate of 150 tons per day for the Chicago-Joliet situation would be very moderate and this would have to be continued for five or six months. Considering the results in Indianapolis, he did not think the expenditure involved would be justified, as he did not believe the nuisance would be measurably reduced.

After reviewing all of the testimony with respect to the use of chlorine upon the Waterway and the Pool, I do not think it possible to say more than that the use of chlorine in large quantities would relieve the odor situation to some extent. In order for one to have any substantial hope of accomplishing appreciable results, it would probably be necessary to use quantities ranging from 75 to 100 tons per day at a per diem cost of $3,000 to $4,000 over a period of not less than 100 days, and it would also be necessary to install chlorinating equipment to cost, on very rough estimates, $360,000 (this figure was given so roughly that I could not have confidence in its accuracy). It would seem too late

now to install the necessary chlorinating equipment for use in the summer of 1941. Upon the concensus of the expert opinion, including that for the opposing States, the Court could have no assurance that even these large expenditures would eliminate the odors in the Pool, although they should reduce them.

The opposing States urge, in connection with their suggestion of chlorination as well as their other suggestions for ameliorating measures, that, conceding room for doubt as to the efficacy of such measures and also conceding a considerable expense to be involved in them, Illinois should be required to try each and all of them before being permitted to divert any more water from Lake Michigan. There is much force in this contention from a standpoint of the general principles of law and equity which would control in an ordinary litigation. As noted in a later section of this report, I interpret the Court's opinion of April 3, 1940 to indicate a view by the Court that if there is actually substantial danger to public health in the situation at Joliet and Lockport, the Court might see fit to allow a temporary additional diversion without regard to the general lack of equity in the position of Illinois unless the Court could be assured that other ameliorating measures are now available which would meet a public health emergency otherwise existing. It may be, however, that even if the Court considered a menace to health to exist, it might deem it proper, in view of all the circumstances in this case, to require that Illinois should exhaust every remedy other than diversion of water which is open to it before being permitted to divert more water from Lake Michigan, even though the proof left it uncertain how much amelioration might be accomplished by a particular measure and even though the experiment would cost very

considerable sums. This question will not have to be resolved if the Court should find that there is no menace to health. It does not seem that an expression of my inclination upon the argument suggested is within the terms of the reference to me or would be of any material aid to the Court, which can itself resolve the point upon the findings of fact that I have made. These findings indicate the uncertainty that must exist as to the extent of relief which the use of chlorine would give even upon the expenditure of large sums.

Cascades at Lockport

The water at Lockport above the dam is diverted through the wheels of a powerhouse and used to generate electric power, which is worth $1,500 a day to the Sanitary District. In 1939 the District generated about 70 million k.w. hours of electricity at Lockport. It transmits this power to Chicago and there sells it to the City at 8½ mills per k.w. hour. The District purchases the power it needs from Commonwealth Edison Company and the Public Service Company of Northern Illinois for something less than 8 mills. The City of Chicago owes the Sanitary District about 4 million dollars for power bills accumulated over a period of years, for which the Sanitary District holds judgments against the City. The present balance of 4 million dollars is substantially less than the amount which was due in 1933 because of payments made in intervening years.

Mr. Howson proposed that instead of using the water at Lockport to generate power, the District should send it over a cascade, which would pick up oxygen that would be available for the B.O.D. demand in the Pool. He estimated that on the present flow, 113,000 lbs. of oxygen could be picked up in this way, at the rate of 6¾ p.p.m. of D. O., which would be equivalent to the

oxygen available from 2,650 c.f.s. of lake water. Mr. Howson estimated that a wooden cascade could be constructed at a cost of between $50,000 and $100,000. This, again, is evidently a rough figure. There would be no operating expense but there would be a loss of $1,500 a day from the sale of power which would be a substantial item. Mr. Howson based his estimate of the amount of oxygen which would be picked up by the cascade, in part upon the experience at Hastings Dam built by the United States Government in the canalization of the Mississippi River below Minneapolis and St. Paul, and in part upon the amount of oxygen picked up in the North Side plant of the Sanitary District, where the effluent flows down through steps.

Mr. Warrick also testified that he believed cascades near Lockport "would have a beneficial effect." He gave particulars of the results obtained at Hastings Dam in 1933 and 1934, where about 7.8 p.p.m. of dissolved oxygen was obtained. He said, however, that he would be unable to express any opinion as to how long the dissolved oxygen picked up by cascades at Lockport would be retained. He doubted whether any would be carried through Brandon Pool, "particularly with the sludge deposits that are testified to in this case", but it would be "an ameliorating step to an extent to which it would supply oxygen to the water."

Mr. Calvert, testifying for Illinois, thought cascades at Lockport would improve conditions "very slightly." "The passage of water over such a cascade would rid it of a great many of the noxious gases already there, pick up a little oxygen perhaps but certainly would not last for a very long time and not remain in the water as dissolved oxygen." He supported his views by reference to an experiment with a dam built in White River below

his plant at Indianapolis where the oxygen picked up was found to be gone within a quarter of a mile to half a mile, with a B.O.D. of around 10. He testified also that cascades would create a local odor nuisance by the agitation of the water containing sludge.

Dr. Mohlman and Mr. Pearse did not think that the experiment in picking up oxygen in the North Side effluent as it flowed out of final settling tanks was sufficient to show that oxygen would be picked up by the cascade at Lockport to the extent claimed by Mr. Howson. They conceded that some oxygen is picked up by cascading and the re-aeration caused by the agitation of the water, but thought the amount picked up in the manner proposed would not exceed 3 p.p.m. and that the effect thereof would be entirely lost before the Pool was reached because of the anaerobic condition of the water.

Mr. Howson contended that the dissolved oxygen picked up by the proposed cascade at Lockport would not be lost because there was a fifteen foot fall from that point to the Pool, which was somewhat comparable to the condition that prevailed at Joliet before the construction of the Brandon Road Dam when they used to pick up about 400,000 pounds of oxygen per day, partly in dissolved oxygen and partly through satisfaction of B.O.D., as shown by the 1925 report of the Sanitary District Board of Review.

Mr. Enslow testified that he agreed with Dr. Mohlman that the re-aeration which would be obtained by the cascading "would not justify the cost in comparison with the value attained on the score that the period is short. You can only pick up a definite amount of oxygen in that period, you cannot go any further and that does not last very long afterwards in summer conditions, and he is eminently right." Later he said that if you would add

some form of pasteurization, preferably chlorine, the aeration scheme might "accomplish something"; otherwise "it would just create a local odor nuisance." Later he said that chlorine with cascading would be beneficial and more so than chlorine alone, but still he thought the 37 foot head existing at Lockport was pretty expensive to use for that purpose.

Mr. Pearse said that if the suggestion of cascading had merit, it would not be necessary to spend the money on cascades as Mr. Howson had proposed, as there would be enough fall over the dam at Lockport to serve the same purpose as the cascades. But he did not think enough dissolved oxygen would be gained for the Pool to justify the loss to the District of the $1,500 which it now realizes through the power generated by sending the water through the wheels at the power house at Lockport instead of over the dam.

It was pointed out by the opposing States that during the ten day flushing test, substantially the same amount of dissolved oxygen was found at the Cass Street Bridge in Joliet (a little over 3 miles below the Lockport power house) as at Lockport, which supported the contention that dissolved oxygen picked up by cascading would be retained as far as the Pool. Dr. Mohlman pointed out, however, that the Des Plaines River enters the stream between Lockport and Cass Street, also that the 10-day experimental flow was made in winter; conditions would be entirely different in summer, he said, as dissolved oxygen would be more rapidly used up in hot weather.

My conclusion upon this suggestion of cascades at Lockport is that while the cascades would develop some dissolved oxygen, the proof is not sufficient to make it reasonably certain that enough of this would be retained

when the wide section of the Pool was reached to sensibly ameliorate conditions there during the summer. There might be some improvement in the short stretch between the point of location of the cascades and the McDonough Street Bridge at Joliet, but this would be offset for a portion of this area by the local nuisance condition which would be created unless chlorine were used; no evidence was offered as to how much it would cost to apply chlorine to the necessary extent.

The opposing States argue that Illinois should be required to try every measure which might possibly ameliorate conditions even though at considerable expense, before becoming entitled to divert additional water from the Lake, and that accordingly the District should submit to the loss of $1,500 a day in power, in order to exhaust the possibility of benefiting conditions in the Waterway through the development of dissolved oxygen by sending water over cascades or over the dam at Lockport. In other words, conceding uncertainty as to the accuracy of Mr. Howson's estimate that cascading would pick up as much dissolved oxygen as 2,650 c.f.s. of Lake water and that this would be retained to Joliet, Illinois should be required to make the experiment even at a considerable expense for the taxpayers of the Sanitary District equal (at the rate of $1,500 a day) to $45,000 a month. The point is the same as that made with respect to chlorination and is sufficiently covered by the comments which appear on pages 90-91 *supra*, although the cost to the District of experimenting with respect to cascades (including the use of chlorine to control the odor nuisance which would result) would apparently be very much less than it would cost to attempt chlorination of the Waterway on any scale likely to produce substantial results.

Supply of Additional Oxygen through Production of Nitrate by Increased Use of Air at North Side and Calumet Plants

Mr. Howson suggested that 40,500 lbs. of additional oxygen might be developed in the effluents in the North Side and Calumet Plants by increased operation of the aeration equipment now existing in those plants at an operating cost of $89,000 for a 5 months period and $216,000 for a 12 months period.

Mr. Warrick thought that the use of an increased amount of air would have a beneficial effect by putting additional oxygen into the effluent and "tending to ameliorate conditions in the water into which it is discharged."

The suggestion was supported in general terms by Mr. Ellms. Dr. Buswell, the Chief of the Illinois State Waterway Survey, testified, also in general terms, that it had been known for many years that nitrates carried oxygen available for B.O.D. satisfaction, and he knew of no streams with nitrates and nitrites present in the water where septic conditions occurred, as nitrates in his experience tendered to oxidize hydrogen sulphide and prevent its formation.

Dr. Mohlman and Mr. Pearse were of the opinion that the production of nitrates by increased use of air would have very little value in ultimate result. Mr. Pearse testified that nitrates do not become available until the dissolved oxygen is exhausted and then you are at the point of nuisance, and the small amount you have obtained is "a drop in the bucket." The production of nitrates would require an increase in the detention period in aerating tanks from the present period of 4.6 or 5 hours to 7 hours, and sufficient aeration tank capacity does not now exist to permit this. In his opinion "the

making of nitrates is not an efficient use of the public's money by a process of this kind." Dr. Mohlman thought that the cost of producing nitrates would be "money thrown away". They would increase the growth of green plant and algae in the North Shore channel, and these plants "die, putrefy and create secondary sources of B.O.D." No dilution would be provided, and the suggestion in his opinion would not result in any increase in dissolved oxygen available at Brandon Pool.

Upon a point of this character it is difficult for a layman to evaluate conflicting opinions of experts. The testimony leaves me in considerable doubt as to the efficacy of the suggestion to make any substantial improvement in the conditions in the Pool. Even upon Mr. Howson's figures, the amount of oxygen which would be provided would be only a small percent of the B.O.D. demand in the Pool. The adoption of the suggestion would, upon the testimony of the District representatives, require a substantial increase in the aeration tanks at the North Side and Calumet plants, which could not now be provided for the summer of 1941.

Chemical Treatment at West Side Plant

Another ameliorating measure proposed by the opposing States and supported by the testimony of Dr. Buswell and Mr. Howson was the installation of chemical treatment for further purification of the Imhoff tank effluent at the West Side Plant. It was estimated that such a treatment would reduce the B.O.D. at that point by 21 p.p.m., which on the May, 1940, flow at that plant of 437 m.g.d.[1] would effect a reduction of 76,000 lbs. of B.O.D. Mr. Howson estimated that this would require an installation costing about $1,300,000 based upon figures given in the April, 1940, report of the Sanitary District to the PWA. This

[1]The average 1940 flow at the West Side Plant was only 362 m.g.d.

would be a building of a permanent nature. He estimated that the cost of operation would range from $200,000 for five months' to $481,700 for twelve months' operation. When he gave his testimony in September, 1940, Mr. Howson said that the installation, if immediately proceeded with, "full speed ahead", could be completed by the summer of 1941, although according to the 1940 District report to the PWA, it would have taken 2½ years. It is clear that this cannot be done now in time to be effective in 1941. It is conceded that the activated sludge program to which the District is committed will be more effective than chemical treatment and that it was chosen for that reason. Chemical treatment would reduce B.O.D. at the West Side from 57 p.p.m. to 36 p.p.m., whereas activated sludge treatment is expected to reduce it to 10 p.p.m. In its April, 1940, report to the PWA Review Board, the Sanitary District estimated that it would cost approximately $555,000 per year to operate a chemical plant at the West Side as compared with $320,000 per year for an activated sludge plant. Consideration of these figures led the PWA to approve the recommendation of the Sanitary District that the Imhoff effluent at the West Side be not chemically treated, but that it be taken to the Southwest plant for activated sludge treatment after the facilities at the latter plant had been sufficiently enlarged. This program has been definitely adopted and by the summer of 1942 substantial progress in its completion should have been made. It would be difficult to maintain at this stage a suggestion that chemical treatment should be adopted as a temporary or emergency measure to care for the summer of 1942 at the cost involved, when it would be almost immediately superseded by the superior activated sludge treatment.

Chlorination of West Side Imhoff Tank Effluents

The application of chlorine to the West Side Imhoff tank effluents was described by Mr. Howson as an alternative to the chemical treatment at that point which has been discussed in the immediately preceding section of this report. The alternative was suggested by Mr. Enslow at the hearings. Mr. Howson estimated that such chlorination would reduce B.O.D. to the extent of 50,000 lbs. as compared with the reduction of 76,000 lbs. which would be obtained by the use of chemicals. The cost of the necessary chlorinating equipment was estimated at $100,000 and the time for construction at 6 to 9 months. The operating expense was placed at $105,000 for a period of 150 days. These estimates were only approximate and not supported by any detailed figures.

It is obvious that the suggested work could not now be done before 1942. The extent of amelioration afforded at that time, would be limited. In view of these circumstances and of the improvement in conditions which should otherwise develop by that time through the permanent program of the Sanitary District, I do not think I would be justified in making a finding that this measure should be adopted.

Planned Use of Water Permitted Under Decree of April 21, 1930

The decree now in force permits the diversion of 1,500 c.f.s. in addition to domestic pumpage, to be determined by the discharge at Lockport. In 1939 the average total flow at Lockport including domestic pumpage was 3,132 c.f.s. while in 1940 it was 3,319. In 1940 domestic pumpage averaged 1,589 c.f.s. Lake Michigan water contains dissolved oxygen ranging from 14 p.p.m. in winter to 8 or 9 p.p.m. in summer. The demand of

the sludge upon the dissolved oxygen in the water is greater in summer than in winter. It is, therefore, more helpful to the avoidance of nuisance to have water in the summer months. Mr. Howson suggested, accordingly, that the conditions at Lockport and in the Pool in the summer months could be improved if the Sanitary District would budget its water supply so as to take a flow of 4,200 c.f.s. during four summer months and correspondingly less in the rest of the year.

Illinois conceded that there was merit in this suggestion, but contended that its application was limited because of the necessity of providing for storm run-offs. In stormy weather considerable water comes into the Chicago and Calumet Rivers. It is necessary to maintain a sufficient flow in the Waterway to prevent a reversal of the stream. If there were such a reversal, there would be danger that the Waterway would flow into Lake Michigan at the Calumet River (the controlling works are only at the mouth of the Chicago River) and thereby pollute the Lake water which is used by Chicago for drinking and bathing. While the controlling works would prevent the escape of any water into the Lake at the mouth of the Chicago River, it is said that a reversal in that river might cause basements in the area of the Chicago Loop to be overflowed. These risks are eliminated by increasing the flow at Lockport when storms occur, thereby increasing the current through the Waterway to the extent necessary to offset any reverse flow tendencies which might be caused by storm waters. Mr. Ramey testified that as rainy seasons vary, the Sanitary District felt it necessary to be on the safe side by making a reserve of water for use in the event of storm.

The opposing States contend that their suggestion can be accomplished without interfering with an adequate

storm reserve. They point out that in July, 1939, (for example) out of the 1,500 c.f.s. which the decree permits, the District took only 995 c.f.s. from Lake Michigan, while in 1940 in the same month the amount taken was 1,700. On December 27, 1940 the flow at Lockport was only 2,397 c.f.s. as compared with a flow in 1939 on that day of 3,895 c.f.s.[1]

In its modified petition Illinois has indicated that it proposes to take only 1,150 c.f.s. of water, in addition to domestic pumpage, in the months of January, February, March, November and December. Thus, it would appear that Illinois really considers no more than 1,150 c.f.s., in addition to domestic pumpage, necessary in the stated months. Tables 10 and 11 in the appendix show that in these months in 1939 and 1940, Illinois actually diverted considerably more than 1,150 c.f.s., in addition to domestic pumpage. The difference between the amounts so diverted and 1,150 c.f.s. might have been made available in the summer months and to that extent would have ameliorated conditions in 1939 and 1940. The amelioration will be available in 1941 and 1942. It appears from the record that the flow at Lockport in January, 1941, was reduced to 2,781 c.f.s. as compared with 2,949 c.f.s. in 1940.

The program set out in the modified petition of Illinois falls somewhat short of the suggestion made by Mr. Howson because the aggregate difference between 1,500 c.f.s. and 1,150 c.f.s. for five months is 1,750. This amount, if divided among the four summer months, would permit in each of those months an additional flow of approximately 400 c.f.s. Adding this amount to the regular permitted flow of 1,500 c.f.s. and to the average domestic pumpage of 1,700 c.f.s. in the summer months, would give a total flow in each of those months at Lock-

[1]See Appendix, Tables 10 and 11.

port of 3,700 c.f.s. as compared with the flow of 4,200 c.f.s. which Mr. Howson thought feasible.

In view of the paramount importance to the health of Chicago of avoiding any reversals of the river, I should hesitate to make a finding that the Sanitary District should be required to go further in budgeting than in its modified petition it admits to be possible. As Mr. Howson's original suggestion would contribute only 22,000 lbs. of oxygen to the B.O.D. situation at Lockport, the lesser amount which will be available upon the admission of the Sanitary District would not be substantially ameliorating.

Metering of Chicago Domestic Water Supply

To a large extent the domestic water consumption is not metered in Chicago. The opposing States offered in evidence a table showing that the Chicago per capita consumption was 214% above the average of 19 other American cities. Of 412,228 water services in 1940, only 115,025 were metered. Universal metering would reduce the amount of water consumed. This in turn would reduce the volume of sewage, which would permit a longer period of detention in aeration tanks and increase the amount of sewage which could be given complete treatment. Reduction in domestic pumpage would, it is true, reduce dilution and the total quantity of B.O.D. in the sewage would remain the same, although less diluted by water. Upon the balance, however, there would be apparently a substantial gain in the amount of sewage which could be completely treated if the water consumption were diminished. I find no evidence in the record sufficient to enable me to appraise the extent of the benefit which would result.

The desirability of limiting water consumption in

Chicago has been frequently urged. The permit of the Secretary of War dated March 3, 1925 (which authorized the diversion of not exceeding 8,500 c.f.s. in addition to domestic pumpage) contained a condition that Chicago meter at least 90% of its water services at the rate of 10% per year. The PWA Board of Engineers in its report of April 30, 1934, stated that the "great and unreasonable waste of water from the Chicago waterworks system" had "added millions of dollars to the cost of sewage and sewage disposal work," and recommended that every effort be made to reduce such waste and "that the capacity of future treatment plants be predicated upon the reasonable use of water". In August, 1938, an offer of grant from the PWA in connection with the construction of the South Side water filtration plant contained a condition that the City must satisfy the Administrator that it would install approximately 115,260 meters. In the spring of 1939, the City was permitted to defer the installation of the meters until a later date than originally specified.

Illinois offered evidence through the City Engineer of Chicago that to provide universal metering, 300,000 meters would be required which would cost in excess of $10,000,000 and would require more than 6 years to install if 50,000 meters could be installed each year. In the 10 year period from 1930 through 1939 the City installed 41,564 meters, or an average of 4,156 meters per year. The greatest number of meters placed in any one year was 16,864 in 1931. The City Council of Chicago has made no appropriation for the purchase of meters. If such an appropriation were made, an indefinite delay would be experienced in contracting for and obtaining delivery of meters.

Mr. Howson testified that he thought it would be practicable to put in 30,000 to 50,000 meters in one

year's time. Even at this rate, it would take 6 to 10 years to accomplish the metering; and the opinion of one man is not a sufficient basis for a finding that the indicated rate of progress could be made.

The matter of the metering of Chicago's water supply was discussed in the report of Special Master Hughes on the re-reference.[1] It was there pointed out that the City of Chicago was not a party to this proceeding and its entry as a party had been successfully resisted by the complainants; that the City had the riparian right to take water from Lake Michigan for the ordinary use of its inhabitants and that if it was sought to prevent an abuse of that right through the taking of an unreasonable amount, it would be necessary to present that issue in an appropriate manner. It is true that the point is presented here in a somewhat different aspect, because upon the re-reference the contention was that Chicago should be required to return to the Lake the water which it was withdrawing for domestic pumpage, whereas in the present hearing it is contended that the reduction of the water consumption of Chicago by metering is an ameliorative measure which is open to Illinois as a substitute for increased diversion from the Lake. The considerations referred to by Special Master Hughes would, however, appear to have force also in connection with the issues now presented. Moreover, there is not before me sufficient evidence to enable me to make a finding that a substantial amelioration of the odor conditions at Joliet would be assured if a considerable curtailment in the domestic pumpage by Chicago could be assured. It seems quite certain that the suggestion could in no event be made operative in time to give any relief in 1941 and very doubtful whether it could give any in 1942.

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[1]See report on re-reference (1929), p. 120.

Activated Sludge Treatment at Southwest Plant for West Side Imhoff Effluent

The effluent from the West Side Imhoff tanks is now being discharged into the channel of the Waterway. As the B.O.D. reduction at the West Side plant in 1940 was only 50%, this effluent in the months of June, July and August, 1940, contributed 205,000 pounds of B.O.D. demand per day at Lockport out of a total demand of 529,000 pounds. If the West Side effluent were taken over to the Southwest plant and there given complete activated sludge treatment, the B.O.D. of such effluent would be reduced by 90%. The Sanitary District is committed to doing this; it is a part of its permanent program upon the completion of which it is now engaged. Mr. Howson was of the opinion that if this part of the program were "organized and pushed at once, it could be done so as to be all or largely in use by next summer". To do this would involve the construction of the following items included in the Sanitary District's permanent program figures:

Conduits	$ 341,300
16 Final Settling Tanks	1,059,700
24 Final Settling Tanks	1,256,200
Conduits, Gate Houses, etc.	610,000
	$3,267,200

Mr. Pearse confirmed that all of these items were taken from the Sanitary District figures but said that there should be added other items aggregating approximately $700,000, which would bring the total up to $4,048,000. The Sanitary District estimate for the entire extension of the activated sludge plant is $4,878,500. Testifying in October, 1940, Mr. Pearse stated that plans for the sixteen tanks referred to in the second item were

now under preparation, work having been started thereon in September, 1940, and the District expected to have the work under contract by March of 1941 and completed some time between June and December, 1942. He gave as the reason for the time spent on the preparation of plans, "We are studying our present tanks to determine how they can be bettered. We do not get the results out of them that we had expected and we have, therefore, got to modify those tanks to some degree".

As to other items, Mr. Pearse stated that the expectation was to put the work under contract by September of 1941 and have it completed by December of 1942. In the opinion of Mr. Pearse, Mr. Howson's proposal eliminated certain essential items without the provision of which it would be impossible to give complete activated sludge treatment to the West Side effluent. Aeration tanks which Mr. Howson's program eliminated would be needed. Also, he said, there would not be, upon Mr. Howson's program, sufficient blower equipment available to permit the de-watering and drying of the output sold as fertilizer, and this would make it impossible to run all the West Side effluent completely through the enlarged plant.

The argument for the opposing States upon this suggestion seems to reduce itself to the contention that by proper diligence the Sanitary District might by the summer of 1941 have given activated sludge treatment to all the West Side effluent and that by proper effort now it can certainly accomplish this before the summer of 1942. As an ameliorating method now in fact available for 1941, the suggestion is no longer open to consideration. As an ameliorating provision for 1942, the decision must rest upon a conclusion as to what the Sanitary District by proper effort could do in the completion

of its program by the summer of 1942. The measure proposed is not a temporary or emergency one to meet 1942 conditions; in substance it is a contention that the permanent program of the District for the complete treatment of West Side flow by the activated sludge method might by special effort be completed by the summer of 1942 instead of only at the end of 1942, as the District claims.

The contention may be well founded. In his report on re-reference Special Master Hughes commented that:

> "Much time can be saved or lost in large building operations according to the attitude which is taken as to the importance of early completion. In the present case, the Court has already laid down the requirement that the work shall proceed 'with all reasonable expedition.' "[1]

The record indicates that the Sanitary District has been influenced, not so much by the desire to make speed, as by the purpose ultimately to complete an efficient system at as little expense as possible to its taxpayers. These are praiseworthy motives when considered from the standpoint of the District alone, but they may not place the emphasis upon expedition to which the legitimate protection of the interests of the opposing States entitles them. Another conflict in interest arises from the fact that the taxpayers of the Sanitary District do not appear to have suffered from any nuisance conditions due to delay in completing sewage treatments; the complaints come only from those residing near the Canal in Joliet and Lockport, who are not taxpayers of the District. The record contains numerous references by repre-

[1]Report of Special Master Hughes on re-reference, p. 69.

sentatives of the District to the importance of saving the taxpayers' money as a controlling consideration.[1]

Notwithstanding the foregoing, considering the extent of the work remaining to be done and conceding the possibility that by special effort it may be somewhat expedited, I would not be warranted upon the record before me and in reliance solely upon the opinion of Mr. Howson, which is challenged by Mr. Pearse and Mr. Ramey, in making a finding that the additions to the Southwest plant could be completed in time to permit the treatment at that plant of all the West Side effluent by the summer of 1942. Six months have already passed since Mr. Howson testified that this could be done. The total cost of the work remaining to be done and

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[1]A somewhat similar conflict of interest was presented to Secretary of War Stimson when, on January 8, 1943, he held that a diversion then sought by the Sanitary District would interfere with navigation and that in the absence of direct Congressional sanction, he was not warranted in granting it "however clearly demanded by the local interest of the sanitation of Chicago."

At that time the conflict of interest was between the sanitary needs of Chicago on the one hand and the commerce of the nation and our relations and obligations to Canada on the other, while at this time the conflict of interests is between the sanitary needs of Chicago and the saving of money for the taxpayers of the District, on the one hand, and the property interests of the opposing States, on the other.

Conclusions similar to those reached by Secretary Stimson were expressed by Secretary Taft in his opinion of March 14, 1907, when he denied an application for the Calumet Sag channel. The Sanitary District then was urging that the change was "essential to the healthful sanitation of Chicago" and that "the threatened injury to navigation is so small as to be negligible." There is a corresponding argument here that the effect upon the level of the Great Lakes of permitting the diversion of the amount of water sought by Illinois in its modified petition is so small as to be negligible.

The opinions of Secretary Stimson and Taft above referred to are quoted in the original report of Special Master Hughes (1927) p. 49, 51, 52. Both of these opinions referred to the possibility of submitting the questions presented to the Congress. A bill authorizing and directing the Secretary of War to withdraw from Lake Michigan, in addition to all domestic pumpage, an annual flow of 5,000 cubic feet per second, to flow into the current of the Lakes-to-the-Gulf Waterway, was introduced by Congressman Parsons of Illinois in the 75th Congress. There were extensive hearings in January, 1938, before the Rivers and Harbors Committee of the House of Representatives, but the bill was never reported out of committee. The bill was re-introduced into the 76th Congress, but no action was taken thereon.

not yet contracted for was estimated on January 1, 1941 to be about $9,000,000, and Mr. Pearse pointed out that the National Defense Program has created additional problems in procuring materials and men.

It is true that the District is not entitled to any grace for delays which have transpired during the hearings or since it filed its petition in January, 1940, for additional water from Lake Michigan. But it is one thing to say that Illinois must suffer the penalty for failure of the District to act with more speed, and another thing to make a finding that in the time now remaining the work can be done. The *per curiam* opinion of April 3, 1940 seems to indicate that the Court might yet permit additional diversion, if paramount considerations of health demanded it and no other adequate ameliorating measures were in fact available, notwithstanding that Illinois was in unexcused default. It would seem that the more time that elapses, the greater will be the difficulty in the position of Illinois. Every increased diversion from the Lakes removes a stimulus to Illinois to speed the work. More than two years have already elapsed since December 31, 1938. That date itself represented an allowance of 9 years from January 1, 1930 for carrying out the entire sewage treatment program, and more than 11 years have now elapsed.[1]

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[1]As long ago as January 8, 1913, in denying a then pending application of the Sanitary District to withdraw 10,000 c.f.s., Secretary Stimson observed:

> "It is manifest that so long as the city is permitted to increase the amount of water which it may take from the Lakes, there will be a very strong temptation placed upon it to postpone a more scientific and possibly more expensive method of disposing of its sewage. This is particularly true in view of the fact that by so doing it may still further diminish its expenses by using the amount of water diverted from the Lakes for water power at Lockport. * * *" This opinion is quoted in the report of Special Master Hughes on the original reference (1927), p. 65.

VI.

SUMMARY AND RECOMMENDATIONS FOR DECREE

Summary of Conclusions

(1) The actual condition of the Illinois Waterway by reason of the introduction of untreated sewage creates in the summer months a nuisance through offensive odors at Joliet and Lockport, but does not present a menace to health. No nuisance conditions were proven to exist along the Waterway at any other points.

(2) With respect to remedial or ameliorating measures available to the State of Illinois without an increase in the diversion of water from Lake Michigan, my findings are as follows:

(a) The dredging of Brandon Road Pool would remove chiefly old accumulations of sludge which have completely or largely lost their potency as causes of nuisance and would therefore be of extremely doubtful efficacy. It would cost between $400,000 and $750,000, plus the cost of providing spoil banks and lagoons. It would present problems as to possible nuisance from such spoil banks and lagoons and require further expense for chlorination. I do not think this is a feasible ameliorating measure.

(b) The draining of Brandon Road Pool cannot be accomplished without some interference with navigation, to which the War Department, which has sole jurisdiction over navigation problems, will not consent. For this reason I do not think this suggestion feasible. There would also be presented problems with respect to the water intake pipes of several industries which take water for industrial purposes from the Pool.

(c) Chlorine is an effective measure to reduce

and eliminate odors, but owing to the size of the Brandon Road Pool and the large sludge deposits therein and the continuing discharge into the Waterway of incompletely treated sewage, it is impossible to make a reasonably certain estimate of the amount of chlorine which would have to be applied to produce a substantial result.

In order to have a reasonable prospect of substantially controlling offensive odors, it would be necessary to spend from $3,000 to $4,000 a day for chlorine, plus several hundred thousand dollars for chlorinating equipment.

(d) Cascading the water at Lockport or sending it over the dam there would be remedial to the extent of producing some oxygen at Lockport. How much oxygen would be produced and how much of it would reach Joliet and the Brandon Road Pool is uncertain and could only be determined by actual trial. The use of the water in this way would cost the Sanitary District $1,500 a day in the loss of power and it would be necessary to use an undetermined amount of chlorine to prevent an odor at the point of cascading.

(e) The supply of additional oxygen through production of nitrates by increase of air on the North Side and Calumet plants is not a feasible ameliorating suggestion for the summer of 1941. The evidence before me is not sufficient to prove that it is feasible for 1942, in view of the testimony of the Sanitary District experts that it would require an increase in aeration tank capacity. The proof before me is insufficient to support a conclusion that this suggestion, if it could be put into effect for the summer of 1942, would be substantially ameliorating.

(f) Chemical treatment at the West Side plant would involve a very large permanent expenditure, which

could not be made effective in 1941 and if it could be installed by 1942 would be almost immediately superseded by the activated sludge treatment which is provided for by the District's permanent program. This does not seem to me a feasible ameliorating measure.

(g) The estimates as to cost of chlorinating West Side Imhoff tank effluents are too uncertain and the opinions of the experts too conflicting as to the extent of amelioration which it would afford, to enable me to make any finding that such chlorination is a feasible ameliorating measure.

(h) It is feasible for the Sanitary District to budget the 1,500 c.f.s. of water now permitted to be diverted in addition to domestic pumpage so as to divert only 1,150 c.f.s. in the months of January, February, March, November and December, and to allocate the aggregate saving in diversion in those months to the summer months. This ameliorating measure will not, however, materially reduce the B.O.D. at Lockport, and will not, therefore, substantially relieve the odor nuisance.

(i) The adoption of compulsory water metering by Chicago is an ameliorating measure, but the evidence before me is not sufficient to enable me to make any finding as to the extent of amelioration which it would afford or the time within which it could be made available.

(j) The provision of activated sludge treatment at the Southwest plant for the West Side Imhoff tank effluent is a very important and feasible ameliorating measure to which the Sanitary District is committed, and toward which it has made some progress. The extent of the progress will depend upon the industry and enter-

prise of the Sanitary District. There is no prospect that this ameliorating measure will be operative in the summer of 1941. It is possible, but doubtful, that by special diligence it might be made operative in the summer of 1942 instead of only by the end of 1942, as claimed by the District.

(k) As additional equipment is installed, it will become possible to give complete treatment during the course of 1941 and 1942 to increased quantities of sewage at the Southwest plant. The progress which will be made during these years and the gradually declining influence of sludge deposits from past years will be operative in the summer of 1941 to improve conditions at Lockport and Joliet as compared with 1939 and 1940, and will be operative to a further extent in 1942. The extent of relief from offensive odors which will be afforded at Lockport and Joliet in the summer months of 1941 is very doubtful, but there is a better outlook for the summer months of 1942. Weather conditions will have an important influence.

Notwithstanding every effort on my part to press the hearings and consideration of this case, one of the three years as to which Illinois originally petitioned for relief (1940) has already passed. The people in Joliet and Lockport have submitted to the conditions which prevailed in the summers of 1939 and 1940 without serious consequences to health. If relief is denied for the years 1941 and 1942, the authorities of the Sanitary District may be spurred to increased efforts in the treatment of Chicago sewage. The hearings before me have already resulted in the putting into effect of provisions as to lagooning of incompletely treated sewage which had not previously been adopted.

Recommendations for Decree

I recommend that a decree be entered dismissing the petition and the modified petition of the State of Illinois for a modification of the decree of April 21, 1930, and taxing costs against the State of Illinois.

Respectfully submitted,

MONTE M. LEMANN,
Special Master.

APPENDIX

LIST OF TABLES

Table No.

1. Expenditures of Sanitary District
2. Total Flow of Sewage, Treated and Untreated
3. Tons of Dry Solids Removed from Sewage
4. Tons of Dry Volatile Solids Discharged to Canal in Sludge, Raw Sewage and Effluents.
5. Sludge Discharged to Canal by Years for 1936 to 1940
6. Sludge and Grit Discharged to Main Channel in Tons per Month, 1939-1940
7. Southwest Treatment Works: Flow, B.O.D., D.O. and Suspended Solids in 1940
8. Percent reduction in B.O.D. and Suspended Solids at Major Treatment Works in 1940
9. Sanitary District Estimates of B.O.D. and Dissolved Oxygen Sources and Conditions from Lake Michigan to Lockport, June-August—1938-1944
10. Flow in Main Dranage Canal—Monthly Averages—1939
11. Flow in Main Drainage Canal—Monthly Averages—1940

APPENDIX—Continued

TABLE 1

Total Expenditures of Sanitary District on Treatment Plants as of December 1 of Each Year[1] as Shown by Reports filed with the United States Supreme Court[1]

1928	$ 63,355,422
1930	95,152,224
1931	99,838,941
1932	100,544,411
1933	100,969,212
1934	107,724,805
1935	118,939,159
1936	135,284,080
1937	150,224,345
1938	159,795,331

As of June 1, 1940 the total expenditures were $165,106,519.

As of January 14, 1941 the total expenditures were $166,318,711; future work remaining to be done was estimated to cost $11,756,900, of which $2,392,000 had been contracted for at that date and $9,364,900 had not yet been contracted for.

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[1]The 1928 figures are as of December 31. The reports filed with the Court do not disclose the figures as of December 1, 1929, and the last report filed is as of December 1, 1938.

APPENDIX—Continued

TABLE 2

Total Flow of Sewage Treated and Untreated in Millions of Gallons Daily (Calculated on Yearly Averages)

	Sewage-Treated	Sewage-Untreated
1928	67	
1929	121	
1930	219	880
1931	338	748
1932	380	686
1933	395	697
1934	374	720
1935	372	663
1936	465	641
1937	546	530
1938	568	469
1939	670	377
1940	930	123

TABLE 3

Dry Solids from Sewage at Treatment Works, Tons Per Day, Yearly Average, Calculated from Suspended Solids Removed

1929	54.1
1930	100.5
1931	150
1932	147.6
1933	167.3
1934	166.7
1935	142.5
1936	196.3
1937	199.1
1938	222.5
1939	305.6
1940	422.7

APPENDIX—Continued

TABLE 4

Dry Volatile Solids Discharged to Canal in Sludge, Raw Sewage and Effluents

Tons Per Year

	As Sludge	As Raw Sewage	As West Side Effluent	As Southwest Effluent	Total
1936	21,432	111,960	12,180	0	145,572
1937	24,613	90,450	20,070	0	135,133
1938	22,450	81,490	19,160	0	123,100
1939	33,865	63,150	14,969	3,674	115,658
1940	14,937	20,290	28,305	12,940	76,472
1941	0	6,720	27,650	6,540	40,910
1942	0	6,720	24,360	6,960	38,040
1943	0	6,720	7,128	4,872	18,720

Years 1941-3 in above table are shown as estimated by Dr. Mohlman

TABLE 5

Record of Sludge Discharged to Canal

Tons Per Year

Year	Sludge and Grit to Channel
1936	36644
1937	42495
1938	44198
1939	53970
1940	20224

APPENDIX—Continued

TABLE 6

Record of Sludge and Grit to Main Channel

Tons Per Month—1939-1940

	1939	1940
January	3318	3949
February	2946	3699
March	3305	2518
April	3319	3080
May	4325	2010
June	4316	2287
July	5942	1866
August	5473	315
September	5338	500
October	6435	0
November	4994	0
December	4259	0
Total	53970	20224
Average	4498	1685

APPENDIX—Continued

TABLE 7

Southwest Sewage Treatment Works

Flow, B.O.D., D.O. and Suspended Solids

1940 Month	Flow M.G.D.	5-day B.O.D. % Reduction	Dissolved Oxygen Outfall	Suspended Solids % Reduction
January	287	91.3	8.6	93.1
February	267	93.0	8.3	92.8
March (a)	197		9.5	
April (b)	252	64.0	7.4	74.0
May (c)	310	59.1	6.0	69.4
June (d)	365	53.8	4.2	63.8
July (e)	287	70.8	4.2	77.0
August (f)	340	61.1	5.1	70.2
Sept. (g)	358	68.1	5.1	73.5
October (h)	361	65.1	5.6	73.6
Nov. (i)	374	61.2	6.4	63.3
Dec. (j)	358	47.1	8.5	50.2
Average (k)	313	67.3	6.6	73.4

(a) Complete Treatment on 161 m.g.d.
(b) Complete Treatment on 122 m.g.d.
(c) Complete Treatment on 142 m.g.d.
(d) Complete Treatment on 130 m.g.d.
(e) Complete Treatment on 168 m.g.d.
(f) Complete Treatment on 176 m.g.d.
(g) Complete Treatment on 236 m.g.d.
(h) Complete Treatment on 248 m.g.d.
(i) Complete Treatment on 222 m.g.d.
(j) Complete Treatment on 139 m.g.d.
(k) Complete Treatment on 192 m.g.d.

APPENDIX—Continued

TABLE 8

Per Cent Reduction
5-Day B.O.D. and Suspended Solids
Major Treatment Works—1940

5-Day B.O.D.

Month	Calumet	North Side	Southwest	West Side	Wtd. Avg.
January	92.0	94.0	91.3	51.9	82.5
February	92.4	94.3	93.0	43.2	80.1
March	91.5	94.0	-----	44.0	70.9
April	91.0	93.8	64.0	45.2	63.9
May	89.7	93.3	59.1	49.5	64.4
June	91.6	93.9	53.8	51.9	63.3
July	91.8	95.0	70.8	51.2	68.0
August	90.8	95.2	61.1	58.6	68.4
Sept.	90.7	96.3	68.1	58.5	71.1
October	88.5	95.4	65.1	57.4	69.3
November	86.1	95.5	1.2	47.2	63.7
December	90.4	94.5	4. 1	40.6	56.5
Average	90.7	94.6	67.3	50.0	67.8
Average April-Dec., Inc.	90.2	94.7	60.7	51.1	65.3

Suspended Solids

January	88.4	88.7	93.1	57.2	82.9
February	90.2	91.2	92.8	48.9	80.5
March	89.4	91.0	-----	52.2	73.6
April	90.9	91.7	74.0	50.2	68.4
May	89.8	93.0	69.4	55.2	69.8
June	91.3	93.2	63.8	61.3	70.3
July	91.6	94.6	77.0	57.8	72.7
August	92.2	94.0	70.2	68.1	75.2
Sept.	91.5	94.4	73.5	65.3	75.3
October	88.4	94.1	73.6	66.8	75.8
November	91.0	91.5	63.3	55.2	67.2
December	90.0	90.1	50.2	49.7	60.3
Average	90.1	92.4	73.4	58.0	72.5
Average April-Dec., Inc.	90.8	93.0	68.5	59.6	71.1

APPENDIX—Continued

The Sanitary District of Chicago

Estimates of B.O.D. and Dissolved Oxygen

Sources and Conditions from Lake Michigan to Lockport

TABLE 9

Average June, July, August, 1938-1944.

LOCATION	1938	1939	1940	1941	1942	1943	1944
SOURCES OF B. O. D. Lbs. per day	Actual Data				Computed Data		
North Side Effluent	11,500	11,100	9,300	9,000	9,000	9,000	9,000
Calumet Effluent	7,800	7,300	4,400	4,000	4,000	4,000	4,000
West Side Effluent	106,200	82,000	205,000	200,000	200,000	67,000	67,000
Southwest Effluent	--------	28,600	155,000	160,000	160,000		
Untreated Sewage	528,000	460,000	85,000	33,000	33,000	33,000	33,000
North Side Sludge	100,000	110,000	36,000	0	0	0	0
Calumet Sludge	10,500	0	0	0	0	0	0
Southwest Sludge	--------	50,000	34,300	0	0	0	0
Total, excl. effect of Sl. Deposits	763,800	749,000	529,000	406,000	406,000	113,000	113,000
Sludge Deposits (Computed Data)	519,000	475,000	237,000	118,500	60,000	24,000	24,000
CONDITIONS AT LOCKPORT							
Flow—c.f.s.	6,752	3,336	3,469	3,200	3,200	3,200	3,200
5 Day B. O. D.—p.p.m.	17.3	30.2	20.6	21.0	17.6	4.3	4.3
—Lbs. per day	630,800	562,300	386,000	361,500	303,000	74,000	74,000
Diss. Oxygen—p.p.m.	0.2	0.0	0.0	0.0	0.0	4.4	4.4
—Lbs. per day	6,070	0	0	0	0	76,000	76,000
SOURCES OF DISSOLVED OXYGEN Lbs. per day							
North Side Effluent	15,800	14,700	12,400	12,000	12,000	12,000	12,000
Calumet Effluent	3,800	4,200	4,100	4,000	4,000	4,000	4,000
West Side Effluent	11,100	8,000	14,300	16,000	13,000	50,000	50,000
Southwest Effluent	--------	7,800	12,400	19,000	26,000		
Dilution Water	216,000	67,200	74,000	64,000	64,000	64,000	64,000
Total	246,700	101,900	117,200	115,000	119,000	130,000	130,000

APPENDIX—Continued

TABLE 10

Flow in Main Drainage Canal

Monthly Averages—1939

Month	Total Flow from Main Channel at Lockport C.F.S.	Inflow from Des Plaines River C.F.S.	Domestic Pumpage Chicago Metropolitan Area C.F.S.	Net Diversion from Lake Michigan C.F.S.
January	2911	10	1488	1413
February	3989	40	1504	2445
March	3200	31	1515	1654
April	2718	23	1689	1006
May	2623	18	1532	1073
June	4227	16	1669	2542
July	2880	7	1878	995
August	2902	3	1801	1098
September	2826	0	1733	1093
October	3022	4	1619	1399
November	2820	4	1518	1298
December	3469	4	1487	1978
Average	3132	13	1620	1499

APPENDIX—Continued

TABLE 11

Flow in Main Drainage Canal

Monthly Averages—1940[1]

Month	Total Flow from Main Channel at Lockport C.F.S.	Inflow from Des Plaines River C.F.S.	Domestic Pumpage Chicago Metropolitan Area C.F.S.	Net Diversion from Lake Michigan C.F.S.
January	2949	19	1566	1364
February	2802	36	1538	1228
March	3167	68	1521	1578
April	3026	66	1523	1437
May	3344	118	1528	1698
June	2876	53	1662	1161
July	3609	38	1854	1717
August	3923	47	1750	2126
September	3125	32	1673	1420
October	3186	27	1525	1634
November	2824	34	1459	1341
December	4996	59	1465	3472
Average	3319	49	1589	1681

[1]The 1940 figures were increased by the temporary flow of 10,000 c.f.s. for a period of 10 days from December 2 to December 12, 1940, permitted by order of the United States Supreme Court entered on November 25, 1940. Excluding this 10-day experimental period, the 1940 total flow at Lockport averaged 3,138 c.f.s. and the net amount diverted from the Lake, in addition to pumpage and excluding the 10-day experimental flow, was 1,546 c.f.s.